ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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VOL. CVIII.—No. 2809.] *LONDON: FRIDAY, OCTOBER 31, 1919.* [*Registered at the General Post Office as a Newspaper.*] PRICE...9d. BY INLAND POST ... 11d.

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STEAM CULTIVATING MACHINERY.
STEAM WAGONS. TRACTORS.
CEMENT-MAKING MACHINERY. 7667

A. G. Mumford, Ltd.,
CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches, BOILER FEED PUMPS.
See Advertisement, page 33, last week.
PATENT WATER-TUBE BOILERS,
AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

John H. Wilson & Co., Ltd.
Birkenhead.
See Illustrated Advertisement
Page 11, Oct. 17.

Locomotive Shunting Cranes

Steam and Electric Cranes,
EXCAVATORS, CRANE-NAVVIES, GRABS, CONCRETE-MIXERS,
SHIPS WINDLASSES, WINCHES, and DECK MACHINERY.
6770
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Craig & Donald, Ltd., Machine
TOOL MAKERS, JOHNSTONE, near Glasgow.
For class of Machine Tools see our Illustrated Advertisement every alternate week. 1358

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Augustin-Normand
67, rue de Perrey—LE HAVRE (France).
3890
Destroyers, Torpedo Boats, Yachts and Fast Boats, Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

Electric Lifts
(UP TO 35 TONS.)
7182
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LIMITED.
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COVENTRY. 610

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HIGH-CLASS ENGINES FOR ALL PURPOSES. also WINDING, HAULING, AIR COMPRESSING and PUMPING ENGINES. 1896

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of all types and sizes.
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TUBES LIMITED, BIRMINGHAM. 8179

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SPEEDS UP TO 45 MILES AN HOUR.
PADDLE OR SCREW STEAMERS OF EXCEPTIONAL SHALLOW DRAUGHT.
Repairs on Pacific Coast
by YARROWS, LIMITED, Victoria, British Columbia. 6876
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SPECIALISTS IN
Drillers & Boring Machinery
for Engine Works and Boiler Shops.
DOLPHIN FOUNDRY, LEEDS. 4847

Yachts, Launches or Barges
Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Od 3551
VOSPER & CO., LTD., BROAD STREET, PORTSMOUTH.

Cochran MULTITUBULAR AND CROSS-TUBE TYPES.
Boilers.
See page 17, Oct. 24. 7263

Electric Cranes.
7183
S. H. HEYWOOD & CO., LTD., REDDISH.

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Drop Forgings
write
GARTSHERRIE ENGINEERING & FORGE CO., 50, Wellington Street, Glasgow. 7898

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— FOR —
EXHAUST STEAM TURBINES COMPRESSED AIR, &c.
STEAM DRYERS,
METALLIC PACKINGS.
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Tank Locomotives
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO., LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 7960

Excavators.
FROM 60 TO 600 YARDS PER HOUR.
D. Whitaker,
7985
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7379
See displayed advertisement every alternate week.
JOHN M. HENDERSON & CO., ABERDEEN.

"Spencer-Hopwood" Patent
Sole Makers:
Boilers.
W. H. SPENCER & CO., HITCHIN, HERTS
See page 15, Oct. 24. 7454

"Aptol" Oils
MEAN
Economy.
Henry Wells Oil Co.,
11, Haymarket, LONDON, S.W. 1.

Iron and Steel
Tubes and Fittings.
6920
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 24, Robertson Street, Glasgow.
See Advertisement page 107.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS, } ROWS PATENTS.
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Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 6729

Tubes and Fittings,
IRON AND STEEL.
Stewarts and Lloyd's, Ltd.,
41, OSWALD ST., GLASGOW.
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WINCHESTER HOUSE, OLD BROAD STREET, E.C.
LONDON WAREHOUSE—167, UPR THAMES ST., E.C.
LIVERPOOL WAREHOUSE—63, PARADISE ST.
MANCHESTER WAREHOUSE—34, DEANSGATE.
CARDIFF WAREHOUSE—122, BUTE ST.
BIRMINGHAM WAREHOUSES—NILE STREET, SHEEPSCOTE STREET, and 10, COLESHILL STREET.
See Advertisement page 28. 7368

Die Finished Castings
ensure rapid production and reduce prime cost by eliminating machining operations. Write for illustrations to AERATORS LTD., Edmonton, London, N. 18.

FLEXIBLE, NON-RUSTING
Metallic Hose-Covering
to protect & strengthen tubing for all pressures and purposes. As supplied for H.M. Govt.—AERATORS LTD., Edmonton, London, N. 18.

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FROM
Stock.
THE
Newall Engineering Co.
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LONDON, E. 17. 7824

Locomotive Traversers
(ELECTRIC).
7189
S. H. HEYWOOD & CO., LTD., REDDISH.

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Duckham's Patent Suspended
WEIGHING MACHINES.—EAST FERRY ROAD ENGINEERING WORKS COMPANY, LTD. LONDON, E.—Hydraulic Cranes, Grain Elevators, &c.
See Illus. Advt. last week, page 15. 7977

Rubber MANUFACTURERS
Belting
GUTTA PERCHA & RUBBER, LIMITED
Toronto - - Canada. 7538

Patent
See's Hydro-Pneumatic **Ash Ejector.**
Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4836

500 Kw. Generator, 440/500
volts, or 220/250 volts, d.c., 330 r.p.m., compound, interpoles; suitable for three wire system.
DIESEL ENGINES suitable for driving the above.
Similar (Two) GENERATORS for 250 Kw., 220/250 volts, 330 r.p.m., d.c.
MOTORS, Several 5/15 HP., 220/250 volts, d.c., compound, enclosed.
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West Walls, Newcastle-on-Tyne. 7969

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GOVAN, GLASGOW. LTD.
London Office—12, Victoria Street, S.W.
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RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORKS, also CAST-STEEL AXLE BOXES. 7312

Tel.: "SONDELA." P.O. BOX 560.
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M.I.Mech.E., M.A.I.M.E.,
CONSULTING ENGINEER, 8036
Pretoria, S.A.
Mining. Industrial. Mechanical.

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Water-Tube Boilers.
6094
MESSRS. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

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GENERAL CONSTRUCTIONAL ENGINEERS, 1916
Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.
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Hurst, Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3552

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 97, Oct. 24. 2462

Matthew Paul & Co., Ltd.
LEVENFORD WORKS, **Dumbarton.** 7699
See Full Page Advt., page 82, Oct. 17.

Taylor & Challen
Presses.
8196
TAYLOR & CHALLEN, LD., Engineers, BIRMINGHAM
See Full Page Advertisement, Oct. 17.

Steel Castings.
THOMAS SUMMERSON & SONS, LTD.,
DARLINGTON. 7553

Electric Transporters.
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REDDISH.

P. & W. MacLellan, Limited,
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RAILWAY CARRIAGES AND WAGONS
OF EVERY DESCRIPTION.
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Aluminium Driving Pulleys Lengthen Life of Belts
See Pulleys Leaflet 7360
by THE BRITISH ALUMINIUM CO., LTD., 109, Queen Victoria St., London, E.C. 4.

B. & S. Massey, Ltd.,
MANCHESTER.
Steam Hammers, Power Hammers, Drop Stamps, Band Saws.
QUICK DELIVERY. LARGE STOCK. 7226

The Manchester Steam Users' Association.

For the prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
Chief Engineer: C. B. Stromeyer, M.I.C.E.
Founded 1854 by Sir William Fairbairn.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 7479

The National Foremen's Association of the Engineering and Allied Trades.

(Registered under the Trade Union Act.)

An Association specially formed to look after the Interests of Foremen on their Supervisory Capacity. A 830

All communications to— Head Offices—
H. W. Reid, 61, High Holborn
General Secretary. London, W.C. 1.

UNJUSTIFIABLE CLAIMS TO MEMBERSHIP OF TECHNICAL INSTITUTIONS.

The Councils of the Institution

of (a) Municipal Engineers and (b) Water Engineers respectively hereby give notice that on a recent occasion an application for an appointment as Surveyor to an Urban District Council contained a Statement which distinctly implied that the applicant had been admitted to Membership of the Institutions in question, whereas this was not the case.

Local Sanitary and other Authorities are hereby notified that the Secretaries of these Institutions will be pleased to verify any claims to Membership made by applicants for public appointments.

This notice is issued not only in the interests of technical Institutions but in those of the public.

B. Wyand,
Secretary, Institution of Municipal Engineers.
Percy Griffith,
Secretary, Institution of Water Engineers.
B 338

Inst. C.E. Exams.—Over 300

successes by Correspondence Coaching. Several prizes. Sec. "O" now prepared. (Designs, Specifications and Quantities). A few vacancies open.—Address, 7434 Offices of Engineering.

Correspondence Tuition.—

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Inst. C.E., I. Mech. E., B.Sc.,

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Inst.C.E., Inst.Mech.E., and

all Engineering Exams.—A Practical Engineer, A.M.I.C.E., &c. (recently demobilised), has now resumed coaching for above by Correspondence, after 11 years' highly successful pre-war experience. Separate subjects may be taken. Excellent testimonials. Fees moderate.—Address, A 605, Offices of Engineering.

A.M.I.C.E. and A.M.I.M.E.

Tuition. Also Postal Courses in Mechanical Engineering, Aircraft Design and Mathematics.—Penningtons, 254, Oxford Road, Manchester.

TENDERS.

COMMONWEALTH OF AUSTRALIA.

Tenders are Invited, up to

8th November, by the Secretary, Australian Arsenal, 6, Maiden Lane, Covent Garden, W.C. 2, for Six Belt-driven Drawing and Stamping Presses, by the Ferracute Machinery Company, U.S.A., lying at Waterford, Ireland.

The capacity is respectively one 30 in. stroke, 100 tons; one 36 in. stroke, 100 tons; one 20 in. stroke, 70 tons; and three 2 in. stroke, 100 ton Stamping Presses. Further particulars can be obtained from above address.

Packing and despatch can be arranged. B 304

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD (Plant and Machinery Section).

For Sale by Tender :—

One Triple-Expansion MARINE ENGINE, as for Patrol Gun Boats, cylinders 16 in., 36 in., 44 in., stroke 26 in., r.p.m. 180, I.H.P. 1400.

For Tender Form and Permits to View apply to the Controller, D.B.1.e., Charing Cross Embankment Buildings, W.C. 2.

Note.—*Surplus*, price 3d. The Official List of Government Property for sale. Published twice monthly. On sale everywhere. B 63

MIDLAND GREAT WESTERN RAILWAY OF IRELAND COMPANY.

OLD MATERIALS FOR SALE.

The Directors of the Midland Great Western Railway of Ireland Company are prepared to receive

Tenders for the Purchase of Old Materials.

Form of Tender, giving full particulars, can be obtained on application to the Storekeeper, General Stores Department, Broadstone Station, Dublin.

Tenders must be posted in time to be received at Broadstone on Tuesday morning, 11th November, 1919.

By Order,
Percy A. Hay,
Broadstone Station, Secretary.
Dublin,
30th October, 1919. B 289

INDIA OFFICE, WHITEHALL, 27th October, 1919.

THE SECRETARY OF STATE FOR INDIA IN COUNCIL is prepared to receive

Tenders from such

persons as may be willing to supply BRIDGEWORK.

The Conditions of Contract may be obtained on application to the Director-General of Stores, India Office, Whitehall, S.W. 1, and Tenders are to be delivered at that Office by *Two* o'clock p.m. on Tuesday, the 25th November, 1919, after which time no Tender will be received.

G. H. COLLIER,
Director-General of Stores.
B 324

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED;

are prepared to receive

Tenders for the Supply of

1. LAMINATED VOLUTE AND HELICAL SPRINGS, for Broad and Metre Gauge Rolling Stock.
2. WROUGHT IRON TIE BARS, for 80 lb. Rail Pot Sleepers (about 31 tons).

Specifications and Forms of Tender may be obtained at the Company's offices.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tenders for Laminated Volute and Helical Springs," or as the case may be, must be left with the undersigned not later than Noon on Wednesday, the 19th November, 1919.

A charge, which will not be returned, will be made of 20s. for each copy of Specification No. 1, and 10s. for each copy of Specification No. 2. Copies of the drawings may be obtained at the Office of Robert White, Esq., M.Inst.C.E., Consulting Engineer to the Company, 3, Victoria Street, Westminster, S.W. 1.

By Order,
W. B. REYNOLDS,
for Managing Director.

Finsbury Pavement House,
London, E.C. 2,
27th October, 1919. B 299

MANCHESTER CORPORATION GAS DEPARTMENT.

The Gas Committee are prepared to receive

Tenders for the Construction

and ERECTION of SIX Pelouse and Audouin TAR EXTRACTORS and FOUR Rotary WASHER SCRUBBERS; also the dismantling and re-erection of two existing Washer Scrubbers, together with valves and connections, on the site of their Bradford Road Station.

Specification, Drawing, and Form of Tender may be obtained on application to Mr. F. A. Price, Superintendent, Gas Department, Town Hall, Manchester.

The Site may be inspected and any futher information obtained on application to Mr. W. Newbigging, Engineer, at his Office, 5, Norfolk St., Manchester.

Sealed Tenders to be enclosed in the envelope provided for that purpose, and addressed to the CHAIRMAN of the Gas Committee, and endorsed "Tar Extractors and Washer Scrubbers," Bradford Road Station, and delivered at the Gas Offices, Town Hall, not later than Five p.m. on Thursday, the 20th day of November, 1919.

By Order,
THOS. HUDSON,
Town Clerk.

Town Hall, Manchester,
28th October, 1919. B 306

MIDLAND GREAT WESTERN RAILWAY OF IRELAND.

CONTRACTS FOR 1920.

The Directors of the Midland Great Western Railway of Ireland Company are prepared to receive

Tenders for the Supply of the

undermentioned STORES. The Contracts to commence from the 1st of January next, and terminate on the 31st of December, 1920.

	No. of Form.		No. of Form.
Asbestos and Packing	1	Oils	26
Barrows and Trucks...	2	Paints, Colours and Wallpaper	27
Baskets and Mats ...	3	Ropes and Canvas ...	28
Brushes, Brooms, &c.	4	Rail Fastenings, Iron	29
Brass Fittings for Gas and Water	5	Rail Fastenings, Steel	30
Bolts, Nuts and Rivets	6	Screws, Split Pins, Nails, &c.	31
Bricks, Slates, Earthenware Pipe, &c. ...	7	Sheet Tin, Lead, Gun Barrel, &c.	32
Chain	8	Steel Tyres, Axles and Plates	33
Cement	9	Steel and Copper Tubes, Copper Plates and Ingots	34
Candles and Soap ...	10	Steel Castings ...	35
Carriage Fittings ...	11	Staffordshire Iron, Wire, &c.	36
Carriage Trimmings...	12	Springs, Steel, and Files...	37
Creosote Oil	13	Soft Goods	38
Drysalteries	14	Timber, &c.	39
Fog Signals	15	Tools	40
Farm Produce Boxes	15A	Tool & Barrow Shafts	41
Glass	16	Varnishes	42
Grease	17	Wagon Covers and Tarpaulins	43
Gas Mantles, &c. ...	18	Waste and Wicking	44
Iron & Steel Forgings	19	Yorkshire Iron ...	45
Iron Castings ...	20		
India Rubber Goods	21		
Lime	22		
Leather and Belting	23		
Lamps and Tinware	24		
Locks, Rainwater Goods & Hardware	25		

Forms of Tender can be obtained, on payment of 6d. each, from the Storekeeper, General Stores Department, Broadstone Station, Dublin. *Please do not send Stamps.*

Patterns and Samples can be inspected at the same place on and after 3rd prox., between the hours of Ten a.m. and Four p.m. (Saturdays, Ten a.m. to Twelve noon).

Contractors cannot be allowed to tender to supply goods to their own patterns, nor can the Company's patterns be sent away for inspection.

The Directors will not consider any Tender unless furnished on the Company's forms; nor any Tender in which any alteration of the form has been made.

The Tenders to be sent in by post, sealed and endorsed on the envelope, "Tender for Stores, Form No. ———," and addressed to "The Chairman, Broadstone Station, Dublin," so as to reach him on or before Ten a.m. on the 18th November.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order,
PERCY A. HAY,
Broadstone Station, Dublin, Secretary.
October, 1919. B 325

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD,

(PLANT AND MACHINERY SECTION.)

For Sale by Public Tender,

MACHINERY AND PLANT. Tenders are invited for the following :—

Hand Power Jib Crane 9 ft., Jib 10 ft. radius, 15 cwt. Mounted on circular table.

One ton Platform Scales on wheels 32 in. square. Portable double ended grinder (emery). Air Compressor by Ingersoll Rand & Co., Type No. 12. 150 lbs. per sq. inch. Air receiver for same, also cooling tank.

One BHP. A.C. 3 phase 50 cycles, Semi-enclosed Motor, 400 volts, direct coupled to 12 in. fan.

Six BHP. A.C. Motor as above with switch and starter but without fan. One Oxygen Acetylene Generator, Cap 20 lbs., with all fittings, also Oxygen cutter with spare nozzles.

Above lying at H.M. Store, Ebor Mills, Bingley, Yorks. Tenders closing, November 26th.

CHILLED ROLLS.

Four Chilled rolls 25 in. dia. by 5 ft. 2 in. long. Footplate for wide rolls. Turning Rest for Sheet Mill.

Lying at The Albert Sheet Iron Co., Ltd., Hill Top, West Bromwich, Birmingham.

Rolling Mills, power feed, will roll from 2 B.A. to ⅜ in. Present rolls take ¾ in. and 7/16 in., double friction clutch drive.

Lying at Rotax Motor Accessories, Ltd., Willesden Junction, N.W. Tenders closing, November 26th.

Large number of C.I. Tanks, some galvanized, also wood tanks, various sizes. Filter Presses, 24 chambers 3½ in. sq. complete with pipes, etc. Mild Steel vessels. Platform weight machines. Air Compressors, Vacuum Pumps. Self landing and delivery hoist, 15 cwt. Electric Fans and numerous other articles.

Lying at H.M. Factory, Sutton Oak. Tenders closing, November 26th.

STEEL TUBING.

About 2500 ft. Lapwelded Steel Tube 3/16 in. thick, with Std. inserted joint for lead and yarn. Various lengths of the following bores: 18 in., 12 in., 4 in. Also a quantity of Bends, Reducers, Cocks, Thimbles.

Lying at H.M. Factory, Victoria Works, Northwich. Tenders closing, November 26th.

Conveyor in dismantled condition, complete with 695 trays, 600 ft. double endless chain and rollers. Paint Sprayer by Aerostyle & Lithos, Ltd., complete with 6 HP. Motor and starter. Grouting Machine by Murray Worisman & Co., Piping, etc.

Lying at No. 6, N.F.F., Chilwell. Tenders closing November 24th.

Two Gasometers 9ft. dia. x 8 ft. deep single lift.

Lying at Messrs. Ardois Factory, Selby. Tenders closing, November 24th.

Portable Band Conveyors, length 24 ft., fitted with 2½ HP. Motor by Phœnix Mfg. Co., suitable for 220 volts D.C. supply.

Stacking Machine, 36 in., fitted with two 15 HP. Siemens Motors suitable for 220 volts, D.C. supply. Stacking height 12 ft. 0 ins.

Tenders closing, November 26th. In charge Shipping Officer, R.A.S.C., West Side, Royal Docks, Grimsby.

MOULDING MACHINES.

Two Moulding Machines for hollow pellets, each fitted with 102 moulds. Moulds contained in troughs of three rows of 17 each.

One machine fitted with two driving plates for ejecting pellets from moulds. These have been used for moulding T.N.T., but should be suitable for numerous other kinds of work.

Lying at the works of Mr. H. Cowles, Ivy Road, Hounslow. Tenders closing November 26th.

Three Cameron Slitters and rewinders for cutting fabric. Eighty cutter wheels, serrated edges.

One Unreeling, Folding and Re-winding Machine complete with motor and starter.

Lying at 44, Chichester Street, Belfast. Tenders closing November 26th.

LAUNDRY PLANT.

12 Frugal Gas Irons with bars, etc.
One Rotary Washer, 24 Wringing Machines.
Three Hydro Extractors, Mangles, Presses and other plant.

Lying at Nottingham, Coventry and Leeds. Tenders closing November 26th.

ELECTRIC COPIERS.

Five Shaw's Continuous (double) Electric Copiers.
Two Hall's do. do. do.
One Drying Machine.
Three American Washing and Drying Machines.

Lying at Hotel Cecil, London. Tenders closing November 24th.

100 Steel Jacks, 20 tons.

Lying at Woolwich. Tenders closing November 24th.

GASHOLDERS AND TANKS.

Two, each 500,000 cub. ft. capacity, complete with spiral guides, carriages, etc. Inner lift 105 ft. x 30 ft. deep. Outer lift 107 ft. 6 ins. x 30 ft. deep. Inlet and outlet pipes 12 ins. dia. Tanks complete with platform, etc.

Lying at works of Messrs. Samuel Cutler & Sons, Ltd., Providence Iron Works, London, E. Tenders closing November 10th.

All Tenders must be received not later than Ten a.m. on the date stated.

Particulars of the above, together with permits to view can be had on application to the Controller, D.B.1. (E), Charing Cross Embankment Buildings, London, W.C.2.

Note.—For particulars of other Government property for sale see "Surplus," price 3d., at all bookstalls; or by quarterly subscription of 2/- post free, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W.1. B 189

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD. (Plant and Machinery Section).

TRAWLER ENGINES. FOR SALE BY TENDER.

Tenders are Invited for Two

Mersey type TRAWLER ENGINES, triple expansion, surface condensers, complete with propeller and shafting. Cylinders 13 in. by 23 in. by 37 in., stroke 26 in. Indicated horse power 600, working pressure 200 lb. per sq. in.

Tenders close Ten a.m., 8th November, 1919.

For Tenders and Permit to View apply to the Controller, D.B.1.e., Charing Cross Embankment Buildings, W.C. 2.

Note.—*Surplus*, price 3d., the Official List of Government Property for sale. Published twice monthly. On sale everywhere. B 62

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD (Plant and Machinery Section).

For Sale by Public Tender :—

Six ¾ in. FOUR-SPINDLE GRIDLEY AUTOMATICS.
20 No. 2 VICTORIA CAPSTAN LATHES, by Selson Engineering Co.
Four ¾ in. No. 59 NATIONAL ACME AUTOMATICS.

Lying at Messrs. Kirby Banks Screw Co., Ltd., Beeston, Leeds.

Tenders for the above must be received not later than Ten a.m., November 22nd.

Tender Forms and Permits to view, and all further information can be obtained on application to the Controller D.B. 1 (E), Charing Cross Embankment Buildings, W.C. 2.

Note.—For particulars of other Government property for sale, see *Surplus*, price 3d., at all bookstalls; or by quarterly subscription of 2s. post free, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. B 335

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the

following STORES, namely :—

	Specification Fees.
1. Galvanized Wrought Iron Water Tubes, &c.	£1
2. Bellows	5s.
3. Anvils	5s.
4. Mantles for Lamps	5s.

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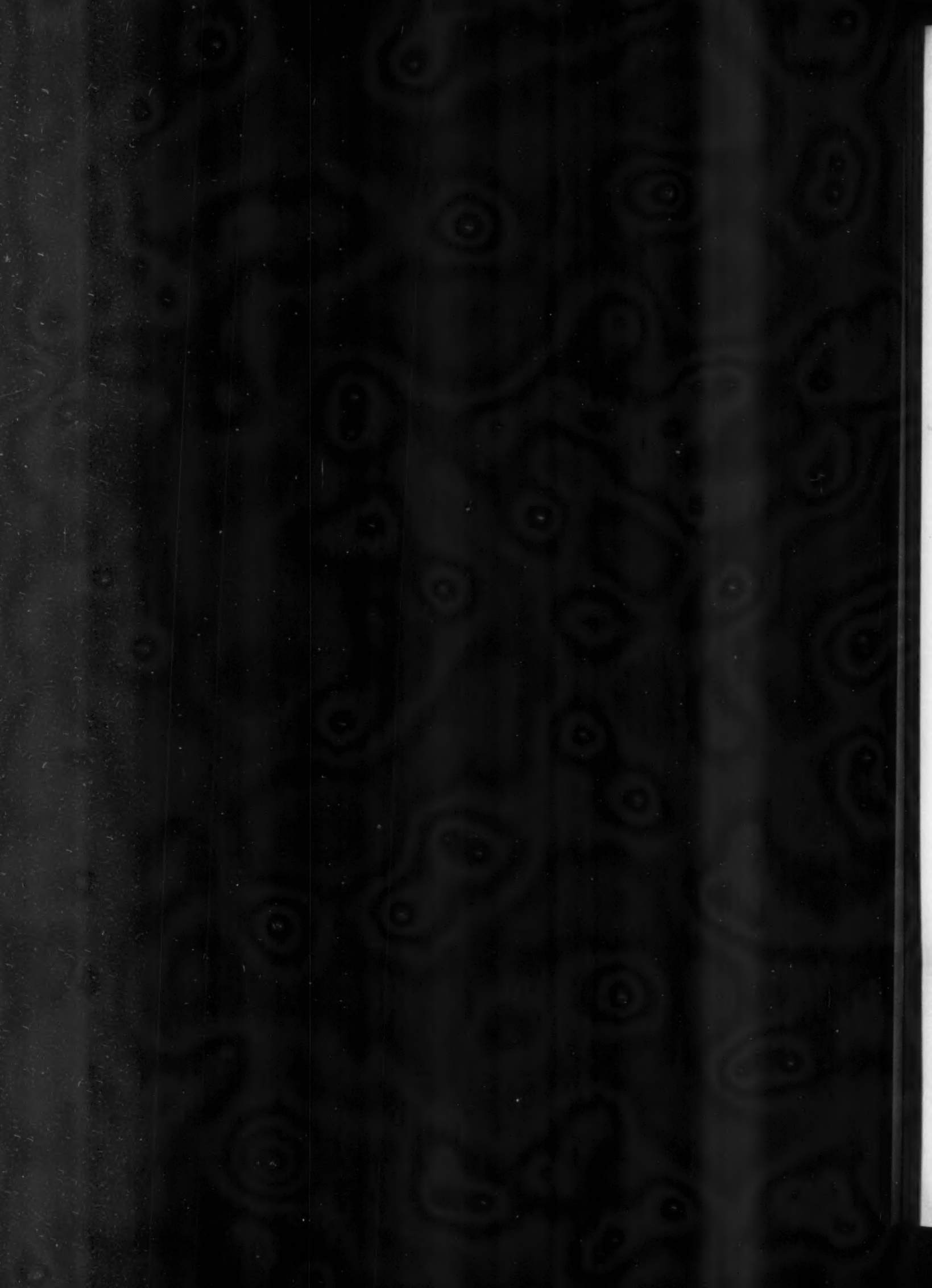
B 59



THE WATER POWER RESOURCES OF INDIA.

The demand and the need for the rapid production of materials of all kinds during the war taught the country the value of the command of power, and demonstrated the advantage electrical energy possessed by reason of its convenience and adaptability. Convinced by this experience we became feverishly anxious to utilise the sources whence this energy could be developed or transformed, and learnt from expert opinion and the reports of committees, that we had treated this store of national wealth with our usual indifference. Though in the Empire the total potential water power amounts in the aggregate to more than 50,000,000 h.p., much of which is capable of immediate economic development, but little systematic attempt has been made by any department of the Government to ascertain the exact possibilities of the hydraulic resources within its territories, or to collect the relevant data that would ensure its most judicious exploitation. Canada and New Zealand have shown unusual energy and, in a lesser degree, the governing authorities of New South Wales and Tasmania have recognised the extent to which abundant water power can aid in advancing the progress of development. In these countries, active steps have been taken to ensure the conservation and utilisation of the water supply throughout large areas. Urged by these examples, and perhaps by the knowledge that Germany had so actively bestirred herself that she had utilised no less than 43 per cent. of her total available water power resources, steps were taken to reassure public opinion that the Government was not unmindful of the nation's welfare in this important matter. As a preliminary measure, the Indian Government and other responsible authorities were directed to undertake a close and systematic investigation of all reasonably promising water powers, and of their economic possibility, though probably no one knew what such instructions entailed or the time required for the preparation of a trustworthy and informative report. The Indian Government, however, had not been entirely neglectful of its duties or wanting in foresight. As early as 1905, aware that the industrial future of the country was intimately connected with, and dependent upon, the provision of cheap power, a circular had been issued inviting the collection of information concerning possible sites where water power might be developed, but since there was no real demand for industrial power on a large scale, except in cases where promoters were making their own arrangements, the matter was not carried beyond this preliminary stage. It is to be hoped that the measures now inaugurated will have a better fate, but in any case it is to be regretted that practically no information has been collected in the intervening fourteen years.

Very considerable weight is behind the present proposals. The Indian Industrial Commission and the conjoint Board of Scientific Studies in London represented the urgency of the situation to the responsible authorities, who at once instructed the late Mr. G. T. Barlow, Chief Engineer, Irrigation Branch, United Provinces, and Mr. J. W. Meares, Electrical Adviser to the Government of India, to set on foot the necessary inquiries that would enable a hydrographic survey of the country to be constructed, and to furnish forthwith a preliminary report. Unfortunately, Mr. Barlow, who entered most energetically into the work, died before the report could be prepared. His colleague, Mr. Meares, has compiled a valuable and instructive statement,* in which he has incorporated the facts collected and recorded by Mr. Barlow, but the latter's knowledge and impressions of localities, many of which were not visited by Mr. Meares, and his wide experience gained in a long life in India, are unfortunately lost to this important investigation.

The object of this preliminary report is two-fold: It explains what has been already accomplished and what are the tasks of the immediate future. At the same time it shows how the work of the investigator may be assisted by those who are intelligently interested, but have had no special training. It is possible that more willingness than capacity will be displayed by these volunteers, but the country to be examined is so vast, that without the co-operation of the public, any approach to a complete survey is impossible within a reasonable time. Up to the date of the report, attention had been drawn to about 130 possible sites of which nothing definite was known, and some have not been certainly identified. In India and Burma there must be many hundreds of sites yet to be examined. For the great perennial snow-fed rivers have been most inadequately explored, and their potential water power cannot even be conjectured. The combined minimum discharges of the Indus and the rivers of the Punjab amount to over 36,000 cusecs (1 cusec flow = 1 cub. ft. per second) where they enter the plains, equivalent to well over 3,000,000 electric horse-power per 1,000 ft. of fall. Similar considerations apply to the Ganges and many rivers rising outside British India to the east, up to the Brahmaputra, and again in Burma, to the Irrawaddy and the Salween. What the total power on the minimum discharges may be is incalculable, while on the normal discharges it is certainly many times greater. These examples are only mentioned here to illustrate the immensity of the subject and to indicate the lax and heedless policy that would leave unexplored these possible sources of power, that could so well minister to the comfort and the necessities of mankind. Of course, it is not intended to suggest that any great percentage of these rivers, remote from industrial centres, is immediately available as a commercial proposition, or that a superficial examination by an unskilled volunteer will decide on the prospects for future development. The assistance of the public is needed only to collect details with regard to existing or favourable sites. If the instructions given are followed faithfully, the information supplied should show where, and approximately how much, power is available. The elimination of those which are worthless, whether for all time, or in the present condition of industry, will be the task of more trained experts.

It is well to consider what constitutes a favourable site, both from a mechanical and financial point of view, more especially as on the one hand vague notions exist as to the value of the power going to waste when water is subjected to a small and fluctuating rise and fall as in the case of tidal estuaries; and on the other, an impression is abroad that "water costs nothing," and somewhat wild suggestions and impossible schemes have been based on that misconception. To those who advocate the utilisation of the immense forces of the tides, it may be sufficient to point out that it is the commercial and not the engineering considerations that must govern the situation, and the second class of reckless advisers must be made aware, that the commercial success of any hydro-electric undertaking depends on the capital charges on the one hand compared with the cost of the competing fuel on the other. Bearing in mind these elementary principles, it is easy to see that a very strict relation must be maintained between the cost of developing the scheme and the quantity of power derived. The power available depends on the product of the fall obtainable and the minimum discharge that can be relied upon in the driest season. In the absence of a definite and ever-present flow of at least several feet, no water power scheme is likely to mature as a commercial success. It may be urged that 1,000 cusecs falling 5 ft. will give the same power as 5 cusecs falling 1,000 ft., but the cost of developing the latter will be far less than that of the former. Hence the best sites are small discharges with long falls, as 50 cusecs to 200 cusecs falling 400 ft. to 2000 ft. Large discharges anything above 1,000 cusecs, falling from 5 ft. to 50 ft., are expensive in construction and rarely worth developing. Mr. Barlow lays down the useful rule, that any site is worth considering if the product of the minimum discharge in cubic feet per second, multiplied by the height of the fall in feet, is not less than 16,000. Since deep falls form a most important factor in deciding favourable conditions, the ideal site will be usually found in hilly or mountainous country, where the snow-fed streams collect in a high-level valley above the fall, and then drop many hundred feet in a short length of the stream into a lower valley. Unfortunately such situations are usually remote from populous centres, and although electric power is already transmitted 250 miles from the power house, and it would be unwise to say that the limit of high pressure transmission has been reached, yet a long transmission line is a costly factor. It is true the loss in transmission can be made almost as small as the designer chooses, or the company is willing to pay for, but this economy in energy can only be attained by increasing the section of the wires employed, and a point will be finally reached at which the cost becomes prohibitive. Such considerations belong, however, rather to the financial than the engineering side of the problem, but in the contemplated extension or introduction of hydro-electric schemes as a source of power the possibilities of transmission acquire great importance.

The general problem is to determine the conditions that will contribute to commercial success; to decide under what circumstances hydraulic power can compete favourably with steam or oil; and to trace the extent that the operations of social and mechanical development will effect the choice of motive power. It must be remembered that Mr. Meares' report is intended to prepare the way for future activities and not necessarily a very near future. The immediate outlook is of less importance than the prospective. In treating of the amount of rainfall and run-off, he contemplates the collection of daily rainfall statistics over a period of thirty years as a preliminary measure likely to give a fairly accurate idea of the hydraulic conditions of the country. A large investment of capital will not be justified without very ample knowledge of the fluctuations in discharge, as in India these are very large, the rainfall in different parts will vary from 450 in. to practically zero, and the effectiveness of a plant is determined by the minimum supply which will be available towards the end of the longest probable period of drought. The utilisation of water power hitherto has been on too small a scale to provide efficient test or to afford accurate data. In 1917, the total electric power amounted to only 215,000 kw., equal to 285,000 electric horse-power, of which 36 per cent. was obtained from water power. Further, there are only three electric schemes in course of construction, so that encouragement is as necessary as information.

Mr. Meares lays down the general proposition that the determining factor in the choice of a power-raising plant will be the cost of fuel in the locality where the power is needed, and that as a consequence the permissible cost of installing a hydro-electric plant may be increased as the cost of fuel rises. This perhaps may be regarded as an axiom at any particular moment, but in preparing for future requirements it does not express the whole of the relations. If coal, or other fuel, is used for steam raising, the material is destroyed, the stock of an irreplaceable commodity is diminished, and the depletion of the oilfields and coal mines is proceeding at such a rapid rate, that their possible exhaustion at least in any particular locality can no longer be regarded with the indifference characteristic of the past. But the hydraulic engineer utilises only the energy and not the water; this may be regarded as a beneficial by-product to be used possibly for irrigation purposes, or in replenishing canals in the dry season, and the stores of the future remain undiminished. The cycle of evaporation, condensation and precipitation goes on unceasingly, however much the available supply in a particular district may vary. It is certain that the cost of fuel will not diminish, and it is perhaps equally certain that the initial cost of installation will advance, piling up the charges for interest, depreciation, sinking fund, and other costs of operation and maintenance. The nice adjustment of the relative expenditure under different systems is a matter for accurate estimate in each case, though the broad principles are as outlined here. One important element fights on the side of the electrical engineer. The load factor is one of vital importance, for as the load factor rises towards the ideal limit, the advantage of hydro-electric power becomes more prominent. The load factor must increase in a country where industry,

* "Preliminary Report on the Water Power Resources of India," by the late G. T. Barlow, C.I.E., and J. W. Meares, M.Inst.C.E., M.I.E.E., M.Am.I.E.E. Compiled by J. W. Meares, Calcutta. 1919.

long stagnant, has become progressive, where the demand for manufactured articles is extending, and where a large population becoming aware of new wants, is eager to satisfy the longing. The load factor which at most stations is of the order of 40 per cent. must assume larger proportions. The total running costs may be regarded as the same whether the plant is fully or lightly loaded—practically the cost is a fixed sum annually—so that the cost per unit is approximately inversely proportional to the number of units generated. In fuel-consuming stations, every extra unit generated involves the consumption of a definite amount of fuel, and though there is some reduction in large plants the saving is by no means proportional to the increased production. Moreover, since hydro-electric power is in its infancy in India, greater opportunities for exercising fuel economies will occur than in fuel combustion plant, whose merits and defects have long been explored. In some favourable circumstances with modern boilers and steam turbines, the consumption of coal is about 1½ lb. per electric horse-power hour, but in the average Indian power stations, the coal consumption is more than 4½ lb. for the same energy generated. The price of coals varies greatly with the length of carriage; in Mr. Meares' representative tables it is assumed that the prices range from 8 Rs. to 24 Rs. per ton of Bengal coal, having about 11,000 British thermal units calorific value per pound.

With such variables it is not possible to assign any very close limits to the sums that may be profitably spent in initial installations, but the following short table compiled from the much more extensive data provided, will give some idea of the effect of the load factor and of the influence of transmission on the initial outlay in hydraulic development. The example, for Mr. Meares emphatically protests against regarding these figures in the light of an estimate, is applicable to an installation of 10,000 electric horse-power, increased by 10 per cent. and 15 per cent., if the power is transmitted 50 miles and 100 miles, respectively. The price of coal is taken as 16 Rs. per ton, and the admissible first cost may be increased in direct proportion to the price of coal. The figures in the successive columns give the maximum permissible capital cost of hydraulic development only, per electric horse-power installed :—

Load-Factor.	Water Power at Site. Admissible Capital Cost per E.H.P. Installed.	Transmission 50 Miles. Admissible Capital Cost of Hydraulic Development per E.H.P. Installed.	Transmission 100 Miles. Admissible Capital Cost of Hydraulic Development per E.H.P. Installed.
Per cent.	Rs.	Rs.	Rs.
20	212	134	80
40	424	322	261
60	636	511	441
80	848	700	622

The differences are not greatly larger than in European installations, where the cost of hydraulic works is said to vary from a minimum of 8.4*l.* to a maximum of 79·6*l.*, per electric horse-power installed. For the majority of the installations the cost lies between 25*l.* and 45*l.* A comparison in absolute price is hardly possible, owing to the fluctuations in the value of the rupee.

In considering hydraulic installation as an enterprise that would recommend itself to capital investment, it is necessary to go a step further and inquire whether the price at which power can be delivered is sufficiently low to provide a market in face of competition elsewhere, and in what directions the energy produced can be usefully employed. A very illuminating example of the efficiency and costs could be furnished by the Tata Hydro-Electric Power Supply Company, but unfortunately no statistics are forthcoming. Here the works are operated entirely from water stored during the monsoon months in three natural lakes, so situated as to provide a fall of 1,750 ft. from the forebay to the turbines. The conditions of installation were most favourable: selection of the site was unhampered by competition or Government regulations, ample capital and wide experience were at the command of the firm, and as far as is known the purpose of the promoters is completely fulfilled. But whether the price of the energy in this or any similar scheme would be low enough to encourage electro-chemical industries is doubtful, for Mr. Meares, with access no doubt to the most accurate and latest statistics and information, writes "where the locality is such that the freight of the plant and materials thereto is low; and where the length of the transmission to the factory is reasonable, power can be delivered at about one-tenth of an anna per unit, including all charges. Indeed, if the cost is much higher than this the proposition becomes untenable." Other authorities state as index to the price of energy permissible, "it may be mentioned that for calcium carbide it should not exceed 0·10 anna per unit, or 3·65*l.* per kilowatt-year, and for aluminium, 5*l.* per kilowatt-year." It is also pointed out that in North America and in Norway, current can be generated from water power at the equivalent of 0·05 anna per unit. "It will be long before any new works, under present prices, can reach these figures," is Mr. Meares' trenchant comment.

We have alluded here to the manufacture of calcium carbide and its derivatives, and to the production of aluminium, rendered possible by the local bauxite deposits, because these, as other chemical processes, being practically continuous in operation, are capable of utilising the whole plant to its fullest extent throughout the year. By maintaining a high load factor they provide good opportunities for the economic application of hydro-electric power. But there is a larger question than the profitable employment of plant. The world's demands for some chemicals, of which fertilisers offer a good example, is so urgent that the resources of Europe and America, great as they are, will be taxed to their utmost to furnish the necessary supplies of the future. New areas of production would be welcomed to relieve the strain on existing factories. The world's consumption of nitrogen, in its various combinations, is about 750,000 tons annually, representing a value of 50,000,000*l.*, and the demand is increasing from year to year. It may be anticipated that as the natural deposits of nitrate approach utter depletion, the stringency will become more marked, because the fertility of the great wheat and cotton-growing areas is diminishing, and artificial fertilisers, the product of some system of nitrogen fixation, will be called upon to satisfy the world's growing needs. It must be admitted that at present the efficiency of electrical production is low, amounting in the case of calcium nitrate to about three-quarters of a ton per electric horse-power year. The resources of the chemist and the skill of the engineer can, and will, be profitably exercised in cheapening the production, but so keen is the demand, that however large the output, it will be readily absorbed. Canada will find her bountiful and economically managed water supply heavily taxed to supply the quantity of nitrates needed to maintain the fertility of her wide acres of arable land. For a long time, India will be quite capable of absorbing the produce of her hydro-electric energy within her own borders.

It can hardly be questioned that the issues alluded to in the last paragraph are sufficiently momentous to warrant State interference and control of water power on all public lands and streams, with the view of preserving the welfare of the Dependency, and of using the resources of the Empire to the best advantage. The legal and administrative problems that complicate the position are best dealt with by an independent authority, the preliminary surveys that facilitate the engineering construction are clearly within the province of the Government, whose duty it is to solve the economic questions as they arise. Particularly important is the prevention of the partial development of the more eligible, or more easily equipped, sites, whose early occupation renders difficult and costly the working of a locality on systematic lines that would utilise the whole of the available water supply to the fullest extent, and in this connection Government authority is essential. Canada and the United States have both suffered from the seizure of water rights by individual owners, and a repetition of the tactics might easily be practised in India. The publication of such a report as the present, calling attention to the most promising sites, places in the hands of the wily or unscrupulous, a mass of information that could easily be abused.

Individual judgment or prejudice will decide in different ways, whether the circumstances disclose grounds for State assistance to private and legitimate enterprise, and in what manner and to what extent Government aid should be given. In past times, the collective effort of those immediately interested would have been expected to finance whatever projects made for the future prosperity of the country. But we have changed all that. On the one hand, there is little inducement to invest in a scheme of development that might be appropriated by the State after being carefully nursed at no small sacrifice into a remunerative undertaking. On the other, the blessed word "Nationalisation" has hypnotised many, who neither understand the motives of its advocates nor can forecast the results of the much trumpeted scheme, but are firmly persuaded that it offers a panacea for all the evils of past shortcomings. These would insist on conditions that would prevent the perpetual rights being lost to the community, though the severity of the provisions jeopardised the prosecution of the scheme.

Probably a safe middle road will be found that will enable the country to enjoy the advantage of cheap power at a comparatively small cost to the Treasury. A proposal that finds great favour is to obtain a guarantee from the Government for interest on capital during construction, and a minimum return after completion, which would be recouped in successful undertakings by some form of sliding scale, or profit sharing, or both. But a policy suitable for one part of India could not be advantageously adopted for the whole country, and the varying circumstances introduce difficulties that the politician finds hard to understand. In some districts, it might be feasible for the Government to advance the capital as a loan, on similar terms to those adopted in the case of municipal loans, with a period of repayment equal to the probable economic life of the plant. In Madras, a novel method was introduced, by the Government starting certain flourishing industries as demonstration plants, and then handing these over to companies as "going concerns," a reversal of the ordinary plan that renders a privately-started public utility undertaking liable to eventual purchase by the Government or a local authority. Such an example as Madras offers, however, has its good points, and is an alternative to be considered. The conclusion at which Mr. Meares arrives is, that direct Government aid is needed, and should be forthcoming, whether by means of pioneer installations or by guarantees to private companies. This view is strengthened by the opinion of the late Mr. Barlow, and by the policy adopted in other countries. In Canada, for example, the Power Commission of Ontario proposes to expend nearly 3,000,000*l.* on the equipment of 12 power stations at various places in the province.

The question of contribution in aid as well as that of the charge for the power supplied needs to be settled on an equitable basis, if industrial progress is to be made, but the problems, not simple in themselves, are further complicated by the rival interests of agriculture and industry. When power is generated from water in canals constructed for irrigation purposes, the manufacturer is utilising works provided for a different purpose, and the irrigation authorities looking to their own interest alone, claim a handsome subsidy for the use of the water, though as explained it is only the gravity that the power man needs. To take another example, the construction of a new reservoir may only be justified on the ground that it serves the combined purposes of power and irrigation, and though the initial capital cost may be proportioned between the two works, it is not so easy to apportion the charge for the water afterwards. The compiler of the report in an illuminating survey of the entire situation, seems inclined to decide the question on broad lines of national expediency rather than on strict legal principles. On grounds of public utility and of equity one may subscribe to the opinion, that "the interests of the State would be better served by the development due to the greater use of water, than by the collection of small sums annually

for the use of water," but the legal niceties remain unsettled.

These side issues are interesting, but they must not be allowed to obscure the main question concerning the prospects of India to be considered as a country suitable for hydraulic development, which was the main purpose of the investigation. So far as the limited time permitted, a very earnest effort has been made to examine all the sites in India and Burma, both new and old, and to collect information on all salient points. This information is presented in the form of notes on the rivers that water the several provinces. The catalogue is long and valuable, but as the details collected are in many instances little more than a list of sites, a collection which the author thinks make dull reading; he has banished this material to appendices, where it is hoped it will escape the ordinary fa e of such treatment and not be overlooked. All sites are included, even those of which practically nothing is known, Until a more extended examination has been made, it is impossible to say which will prove worthless and which will repay further investigation. The general conclusion from the whole mass of information is, that there is a reasonable prospect of obtaining power to the extent of about 1,774,000 electric horse-power. This preliminary estimate is vastly below the available power which a more complete survey will disclose, but it is to be feared that the total, will be considered distinctly disappointing, because the topography of India has been held to be particularly adapted for the collection and distribution of water power. The country is known to be rich in rivers, and the great variation in level provides the "high head" so dear to the heart of the hydraulic engineer. Moreover, our imagination has been excited by tales of potential horse-power, that run into many millions, and such enormous figures would be amply justified, if cost were no object and power could not be obtained by other means.

The British Water Power Company have announced that a potential 7,000,000 h.p. could be derived from the upper reaches of the Irrawaddy and Chindwin Rivers, if a 500 ft. fall could be secured. It is questionable if more than 50 ft. could be obtained at any one place, and then only by prodigal expenditure on dams and reservoirs. Storage during the dry seasons between monsoons is particularly difficult, because the limestone which forms a large portion of the hills is deeply fissured. The way that hopeful prospects di appear under close examination is well illustrated by a site in the Khasia Hills, where the rainfall over 100 sq. miles amounts to 410 in. annually, and the surrounding districts, embracing an area of 1,200 sq. miles, receive a supply decreasing from this maximum to about 100 in. The general elevation is 4,000 ft. above the plain, the slope steep and sometimes precipitous, and the run-off is very large. By simple calculation, the potential horse-power of this small area is of the order of 4,000,000 h.p. But only a very small fraction will ever come on the market, for under strict examination one after another of these advantages disappears. Not the 4,000-ft. drop, nor the half of it, could be obtained, except by a succession of separate developments. "Secondly, the incidence of the huge rainfall is such, that even with favourable reservoir sites, it could not for the most part be impounded; thirdly, these sites do not even exist." This example illustrates the fallacies that underlie such estimates.

The circulation of such exaggerated reports is to be regretted, more especially as failure to realise these extravagant proposals is likely to bring our engineers into disrepute. Already Mr. Meares states that the impression is gaining ground that the importation of engineers from abroad is essential to the proper erection of water power plants. This no doubt is a constructive libel, quite undeserved, on a highly-trained and competent staff, but the numbers engaged on power problems may be too small. In this connection, we would desire to associate ourselves with the Water Power Committee of the Conjoint Board of Scientific Societies, who have reported that it is of the highest importance, that the engineers of Great Britain should be prepared to take a commensurate part in the development of water power schemes. "In the past, large-scale hydro-electric engineering has been confined very largely to Canadian, American and Continental engineers and corporations, and unless some definite and early endeavour is made in this country to make up the leeway, it is probable that the bulk of the Empire's future water power will be developed outside the country." The reputation and capacity of the British engineering industry are not imperilled yet, and we look confidently to the universities to make good any deficiencies in the number of skilled scientists required for this special work.

THE MASS OF THE LITRE OF AIR AND GAS MIXTURES.

A MEMOIR on the Mass of the Litre of Air, a summary of extensive researches, published by Professor A. Leduc in vol. xvi of the Travaux et Mémoires du Bureau International des Poids et Mesures, suggests several important considerations, to which C. E. Guillaume draws attention in a preface to the memoir. Gas densities are referred to air as standard. When relatively large evacuated vessels are balanced by means of small platinum weights, an allowance is made for the buoyancy of the air. In such determinations the composition and density of the air are tacitly assumed to be constant, the data having been reduced to normal temperature and atmospheric pressure. But the air density is not constant, and the buoyancy is sufficiently affected by a barometric change of a few millimetres quite to upset balance established even between lumps of quartz and of platinum, each weighing 1 kg.; for the difference in these two buoyancy effects amounts to 400 milligrammes. It is true that the air density does not fluctuate, under ordinary conditions, by more than a few parts in 10,000; but that deviation is well within the limits of precise measurements. Oxygen being heavier than nitrogen becomes concentrated in the lower atmosphere; owing to atmospheric disturbances by winds and convection currents, however, the composition of the atmosphere cannot be calculated from the latitude and the altitude, though fortunately the same reasons keep the lower atmosphere, in which we move, of a steady composition. On the other hand, the air in laboratories may be seriously contaminated with other constituents, notably with water vapour and carbon dioxide, which we remove by absorption before analysing the air, but which we disregard in density determinations. It would be safer, therefore, to refer densities to a pure gas rather than to air, and as oxygen has long since been adopted as standard by chemists in their tables of atomic weights (O = 16; formerly H = 1), oxygen appears to be the most suitable reference gas.

There is another objection to the use of a mixed gas like air as standard. When Dalton, about a century ago, formulated his law: that the pressure of a gas mixture is equal to the sum of the pressures which each gas would exert if it occupied the same receptacle alone at the same temperature, it was not known that nearly all gases are more compressible than they should be according to the law of Boyle and Mariotte (of about 1662) that the volume of a gas varies inversely as the pressure upon it. Berthollet's experiments on mixtures of hydrogen and carbon dioxide were supposed to support Dalton; they do not, as Leduc points out. If we have equal volumes of two gases, A and B, at equal pressure P and allow the gases to mix, A will not, in the doubled volume, be at the pressure P/2, but at a pressure $P/2 + \epsilon$, because the gas is more compressible than it should be; similarly B will be at a pressure $P/2 + \epsilon_1$, and the pressure of the gas mixture will be $P + \epsilon + \epsilon_1$; but this $(\epsilon + \epsilon_1)$ is not a constant and depends upon the nature of the gases. In one series of experiments to demonstrate this Leduc and Sacerdote connected two flasks of equal volumes, charged with various gases, by a three-way cock, and hastened the mixing of the two gases by cooling and heating the one or the other vessel and by shaking. Diffusion was very slow; sometimes it took days and weeks to obtain a mixture of constant composition (as shown by analysis) and pressure. In the case of two substances like CO_2 and N_2O (which physically differ little) there was no distinct increase in pressure; in the case of two gases like H_2 and SO_2, physically dissimilar, there was a pressure rise of 3 mm. It is clear, therefore, that the nature of the gases has to be considered. What is less clear—from the brief account in the memoir, at any rate—is whether all possible chemical and other disturbing effects can be allowed for in such experiments, and whether Leduc's version of Dalton's law meets the required conditions, namely, that the volume occupied by a mixture of gases is equal to the sum of the volumes occupied by each of the constituent gases at the same temperature and at the pressure of the mixture. As regards the atmospheric mixture of nitrogen and oxygen, the ϵ may practically be disregarded, Leduc finds; but the fact could not be presumed.

The determination of the mass of the litre of air necessarily involved a great many experiments. They were made with volumes of air or of the pure gases amounting to several litres and, in the case of the rare gases, to smaller bulks which Leduc received from G. Claude and subjected to further purification. The average composition of the Paris air (more exactly, of the air, on the fourth floor of the Sorbonne) by volume I and by weight II, is found to be:—

—	O.	N.	A.	Ne.
I	0·2100	0·7806	0·0094	15×10^{-6}
II	0·2321	0·7549	0·0130	$8{\cdot}4 \times 10^{-6}$
—	He.	H.	Kr.	Xe.
I	5×10^{-6}	1×10^{-6}	50×10^{-9}	6×10^{-9}
II	$0{\cdot}7 \times 10^{-6}$	$0{\cdot}07 \times 10^{-6}$	140×10^{-9}	30×10^{-9}

Thus the rare gases (excepting argon) and hydrogen would only affect the fifth decimal of the air density, which is anyhow uncertain, and may hence be neglected. Samples of air taken in different parts of France, and also in Algiers, on the beach at Dieppe, on an alpine peak, 2,060 m. high, with ascending and descending air currents, in balloons, and in summer and winter, show that the oxygen proportion by weight varied between 0·2305 and 0·2325. The oxygen proportion was lower than the average in the north of France at sea level; that, it is suggested, might account for the slightly lower oxygen-values of Rayleigh. Considering the fluctuations of the few figures given the conclusion looks bold; but it is certainly noteworthy that Leduc and Rayleigh differ when the densities are referred to air as standard, while they agree when the figures are referred to oxygen. With respect to samples from the higher atmosphere, we may hope that further data may soon become available. In the woods near Paris, Leduc observed less oxygen close to the soil than higher up within the foliage. The very careful density determinations yielded for oxygen prepared from permanganate 1·10527 (Paris air = 1) and for electrolytic oxygen 1·10521; the accepted mean value is 1·10523 (Rayleigh 1·10532). Nitrogen chemically prepared by various methods gave the density 0·9717 (air = 1) and 0·87508 (oxygen = 1); atmospheric nitrogen gave, in nine determinations, 0·9719 to 0·9721 (air = 1). The nitrogen was isolated from the air by passing the pure air over hot reduced (and therefore porous) copper or by keeping the air over phosphorus; in the former process the temperature of the copper must not exceed low red heat, lest any hydrogen (retained during the reduction of the copper) be liberated and combine with oxygen. It speaks well for the portable oxygen-absorption apparatus (by means of phosphorus) of Leduc that simultaneous determinations with two apparatus gave identical results. The final result is that the litre of air, at 0 deg. C. and 760 mm. barometer, weighs 1·2928 grammes, when $g = 980{\cdot}665$. Under the pressure of one megabar, taking the density of mercury as 13·5951 and g at the Sorbonne laboratory as 980·97, the mass of the litre of air would be 1·2759 grammes.

IMPORTS INTO BELGIAN CONGO.—By a Belgian law passed on October 8, merchandise going to the Congo or other territory administered by Belgium in Africa will be examined at the Customs House, Antwerp, instead of on arrival in the Belgian Colonies, as hitherto.

RECENT MACHINE TOOL DEVELOPMENTS.—No. VII.

By Joseph Horner.

Housings.—Figs. 103 and 104 show the design of housing or upright now adopted for planing machines and plano-millers. It is excellently calculated to resist the stresses that tend to bend it backwards from its area of support on the machine bed. It is better than the earlier triangular housings where the hinder member—the hypoteneuse—was a straight diagonal. The parabolic outline gives increased metal high up where the pressure of the cutting is imposed. The lightening holes take out metal where it is of no use. The plain round holes do not weaken the framing as did the openings in those slenderly-ribbed designs where too much was taken away from the interior, leaving insufficient substance to resist forces that set up vibrations. Since housings are invariably boxed, the thin metal is consistent with ample strength and stiffness. These castings are moulded on their side, and the core print is put on the foot. The space between the slideways is taken out with a core, the print for which is put on that face. The lightening holes can either be cored, or deliver themselves freely, in which case they must be surrounded with wood blocking, fitted between the plated sides of the boxed-up pattern.

Fig. 103.

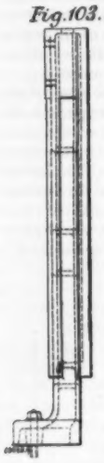


Fig. 104.

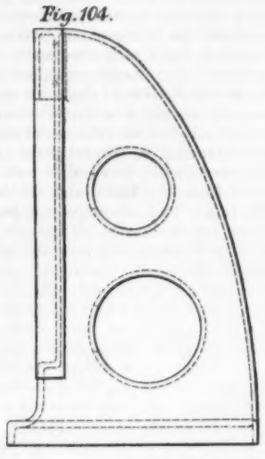


Fig. 105.

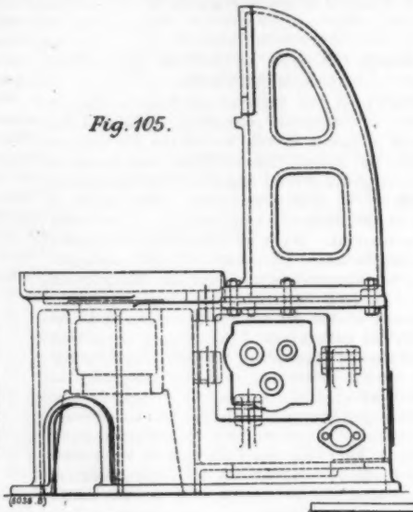


Fig. 106.

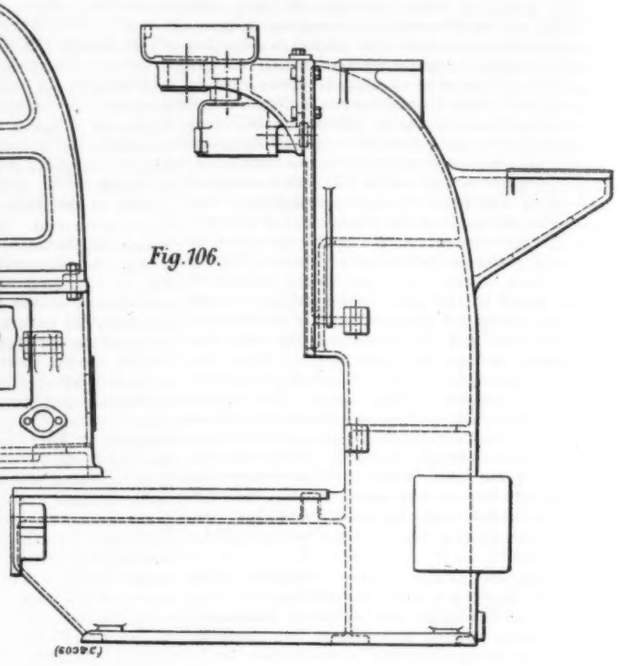


Fig. 107.

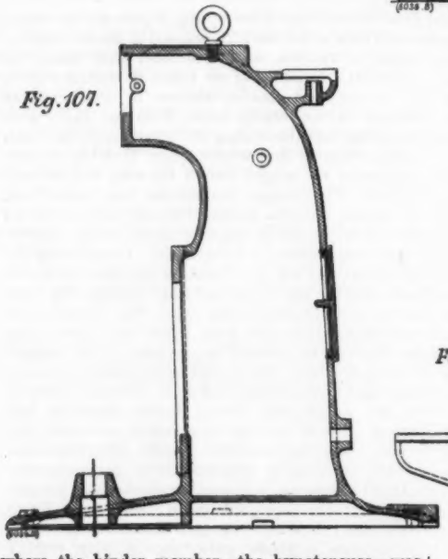


Fig. 108.

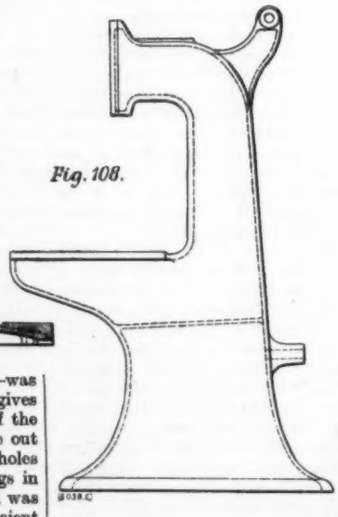
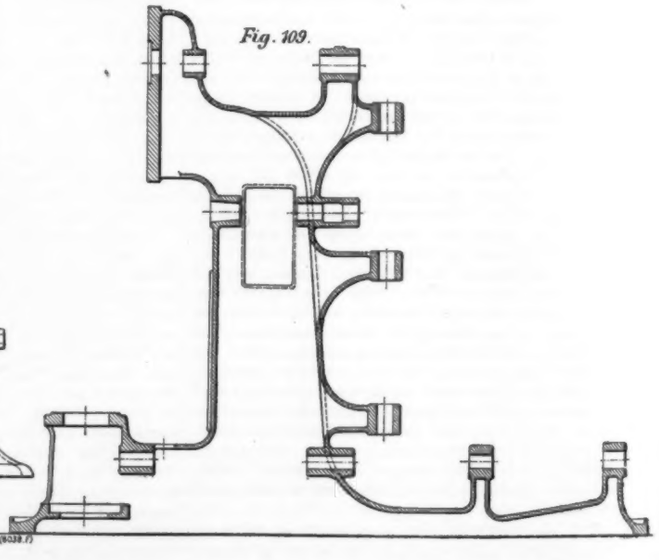


Fig. 109.



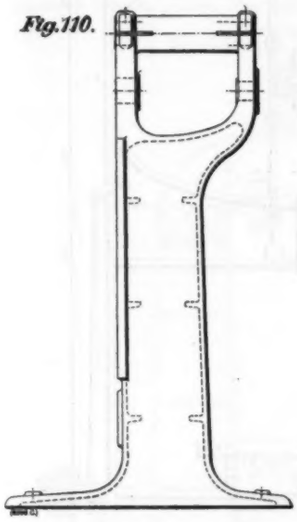
Boring and Turning Mills.—A side view of the framing for a Webster and Bennett double boring and turning mill is shown by Fig. 105. The base, carrying the seatings for the two tables is cast separately from the housings, which are bolted down on it. Sometimes, in the case of the smallest single-spindle boring mills the base, housing, and cross slide are cast in one piece. In the heaviest machines, the housings, as in planers, are carried down the whole depth of the sides, with vertically-fitting faces. In this machine the cross rail is carried and supported on the upper portions of the housings, rigidly, because it has no provision for effecting vertical adjustments as in the heavier class of boring mills, and in planers. The method of lightening shown is a variation of that in the previous figure—the parabolic outline being retained. This is the drawing of a 30-in. mill—that is, 30 in. is the diameter which can be swung, the two tables being located at 3 ft. 6-in. centres. The thrusts of heavy boring and turning are severe, and the housings therefore have broader feet than they have on planers, in this rather small machine they are 12 in. wide, and the flanges that receive the cross rail are 12 in. wide. This rail fulfils the double function of supporting the tool carriage, and of tying the housings together at the top, which, in machines where the cross rail has vertical adjustments, is fulfilled by a stretcher bolted between the housings.

The base casting, 2 ft. high, is about 5 ft. 6 in. long, to include the seatings of the two work-tables. These seatings are well tied together with ribbings. The base extends behind the table seatings to receive the housings above, and various gears and shafts for the table speeds and reverses are provided for below. Bosses in the main casting are provided for some of these, but others are carried in brackets attached to the facings seen. The fittings for the driving shaft lie without the base, those for the transmission sections, within it. The large deep boss for the reception of the table spindle bush, measuring 9 in. in the bore, by 12 in. deep, is cast with the base, and is sustained rigidly central with four ribs at right angles that tie it to the outside walls of the casting. An annular rim above extends to the faceplate, and encloses the driving wheel and pinion. The ample and judiciously distributed ribbing, and the utility design, is secured without any excess of metal in any locality, and risks of internal strains are eliminated. The thickness throughout only averages from $\frac{5}{8}$ in. to $\frac{3}{4}$ in.

Vertical-Spindle Milling Machines.—The main

framing for a Kendall and Gent vertical milling and profiling machine, Fig. 106, comprises in one casting, the upright, the bed for the work-table, and the bracket to the right, near the top, that carries the box of gears for driving and reversing the spindle. A horizontal facing on the top carries the motor, whence the movements of the machine are actuated. A square facing on the side, low down, receives the box of gears for the table drive. A bracket, shown bolted on the top vertical face of the upright, sustains the gears that have charge of the immediate driving of the spindle. The vertical face immediately below this forms a slide-way for a bracket that supports the lower end of the spindle. A lower steady bracket is hinged in the boss adjacent, to be flung aside, or brought into alignment with the cutter arbor.

Fig. 110.



The outlines of the frame are those generally suitable for vertical-spindle milling machines, drilling and slotting machines, comprising essentially the vertical, approximately semi-parabolic member for the toolhead, and the horizontal slideway for the work-table. Variations in details are made to suit the requirements of individual machines, and to harmonise with the views of the designer.

A casting of this kind is moulded on its side. In this case there is no other practicable way. The prints for the main core are attached to the foot, and the vents are brought out there. The metal, averaging $\frac{7}{8}$ in. thick, is reinforced in the upright with internal ribs. The core for the bracket at the top right hand is made separate from the main core. A hole is cast in the diagonal face to bring away the air from the core, and to remove it through. The reason why this bracket is cast in one with the main frame, and four other boxes and brackets are made separately, and attached to facings is not that casting all these in one would be impracticable, though this would materially increase the work of coring. The principal reason is, the greater convenience of handling them separately for tooling, boring, facing, drilling for the gears and shafts with which they are fitted. These operations can be performed more readily and cheaply on the small boxes and brackets as separate castings than they could be if in one with the main casting, since this would involve much turning about, adjustment, and loss of time, consequent on the large number of separate toolings. Questions of this kind must often arise when the subject of casting intricate frames entire, or with some portions separated is under consideration. And the now general employment of boxes of gears for speed and feed changes in place of stepped belt cones has increased the number of bosses, shafts and spindles, with the provisions for effecting their several movements. Gear boxes are therefore almost invariably made and fitted as separate elements—units, that will interchange on a number of machines.

The main frame for a vertical-spindle, high-speed, belt-driven milling machine is shown by Fig. 107. Since the table knee in this design is adjusted for height on the face of the lower vertical slideway, the framing has no horizontal bed to afford table support. The frame is therefore extended instead to form a foot, with a boss into which a bush is fitted to receive the screw that provides the vertical adjustment for the table knee. The vertical face on the upper part of the frame receives a bracket for the spindle and its driving gears. One of those minor details often neglected, but are appreciated, is the eyebolt at the top, by which the machine is slung during transport and erection. A frame like this is easily moulded. The openings are utilised for core prints and for the escape of vents. The recessed base must be cored.

Fig. 111.

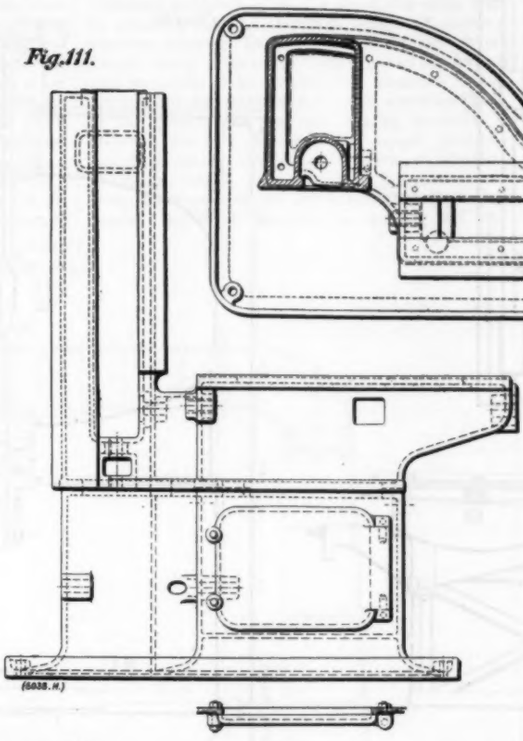


Fig. 112.

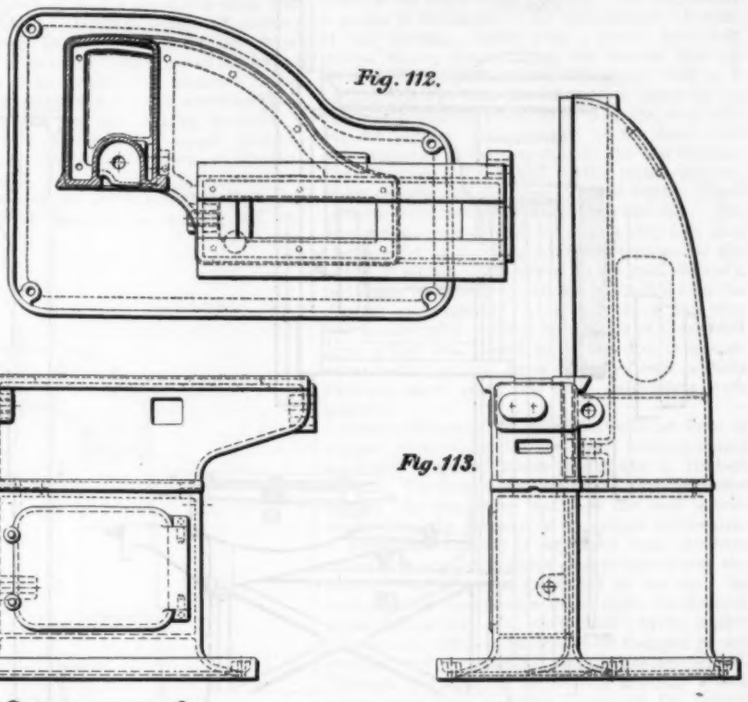


Fig. 113.

Fig. 114.

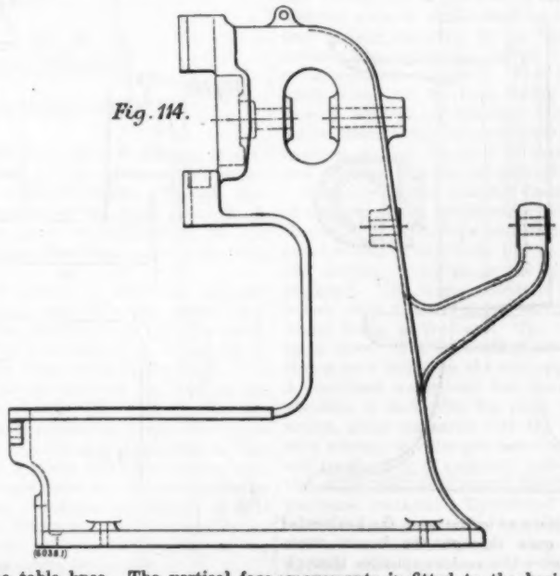


Fig. 108 is the framing of a small high-speed, belt-driven milling machine, standing only about 5 ft. high. It is driven from a stepped belt pulley, the boss for which is seen at the lower right-hand side. The belt runs over two guide pulleys, for which the top right-hand bracket is provided, to a horizontal pulley carried on a sleeve that surrounds the spindle. The spindle bearings are contained in a bracket that is bolted against the horizontal facing on the top, and a lower bearing. A sliding bearing on the vertical face supports the lower end of the spindle, and feeds it. A table with compound movements is fitted to the horizontal slide ways. The base of this boxed casting has an area in cross-section much larger than that of the moiety above the work-table. The sides are tied with a web. At the front the outline is deeply recessed so that the attendant can readily get at the work-table. The upper portion of the framing has thicker metal at the front, where the greater stress comes, than at back. The core that takes out the lower portion of the frame cuts through the base, that for the upper part cuts through between the slide ways for the work-table, being supported elsewhere on chaplets.

A good example of a self-contained framing,

Fig. 109, illustrates the large possibilities of single-piece casting. It is that of a milling machine of special design, since it employs three spindles, two disposed vertically, one above, and one below, coming up through the work-table, while the third runs horizontally, through the bosses seen in the upper part of the frame. All these are driven primarily from belt cones in the base, the horizontal shaft for which goes through the bosses there shown, driving thence the various spindles through their respective bevel gears and shafts. The head for the upper vertical spindle swivels on the vertical face of the frame for angular milling. All brackets for carrying the horizontal and upper vertical driving shafts are cast with the main frame, and cored to maintain the same uniform thicknesses of metal throughout. The lower vertical spindle is carried in bearings in a separate casting seated on the return flange shown. It is stepped into a bush in a casting, for the reception of which the lower seating is provided. A knee, supporting the work-table, is adjustable on the vertical slideway. The casting, the cross-section of which is rectangular, and nearly square, must be moulded on its side. The core can very well be made in one piece, or the narrow section in the base to the right might be conveniently rammed in a box separately from the main body. A print is put on the bottom of the framing—one side in moulding, and the core is also supported through the opening seen in the upper part of the frame, adjacent to the bosses there. Either holes with allowances for boring should be cast in the bosses, to prevent drawing of the metal or, which is generally preferred, when holes are small, they are left solid, and the bosses fed. None of these bosses tie adjacent portions against shrinkage, so they are not elements of weakness.

Horizontal-Spindle Milling Machines.—The up-right of a small milling machine of the pillar-and-knee design is shown by Fig. 110. It is, as is usual, belt-driven with back gear. The ends or uprights of the headstock are tied together by the split boss above. Through this the steady arm passes and is adjusted longitudinally, and clamped to suit cutters and arbors of different lengths. The knee slides on the vertical ways at the front. The elevating screw runs in a bracket bolted to the facing seen below the knee slide-ways. The base is sufficiently broad and stable, being brought out under the overhang of the head in the rear, and prolonged at the front beneath the knee and work-table. This, in its broad outlines is the design that has been long standardised.

Fig. 115.

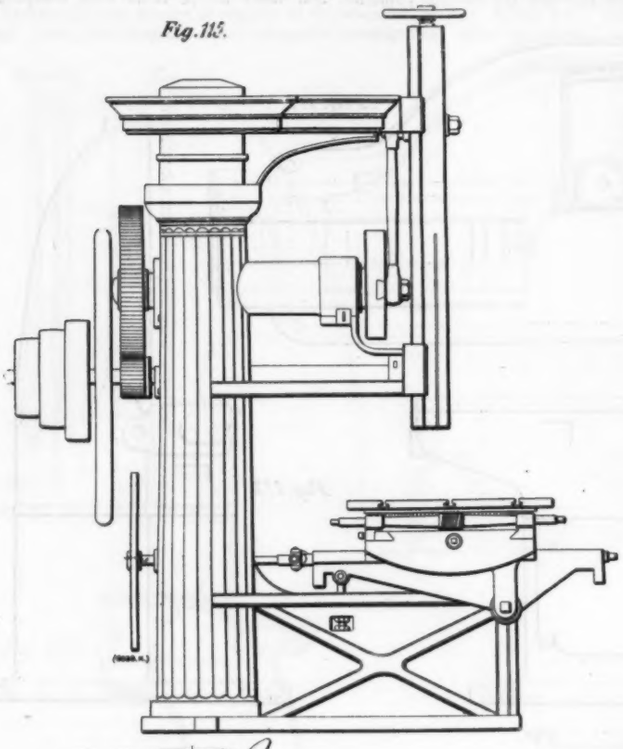


Fig. 116.

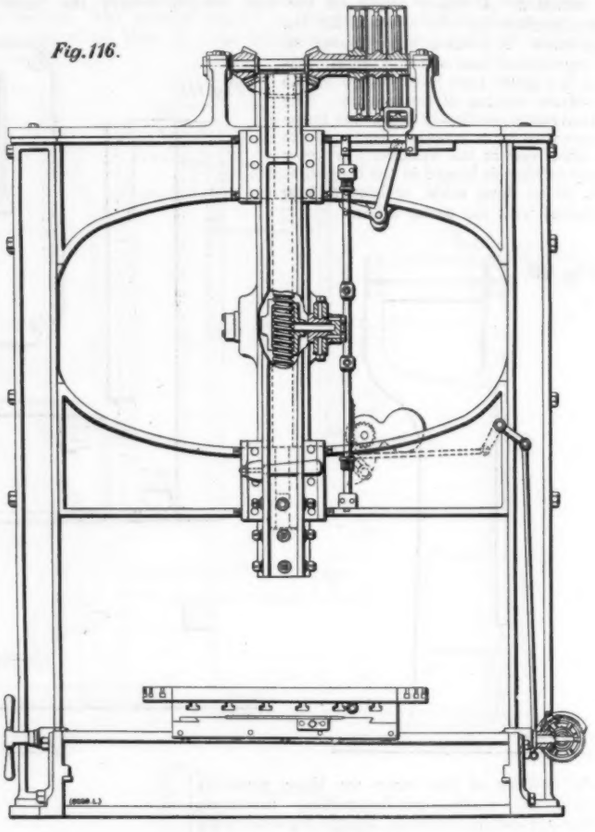


Fig. 117.

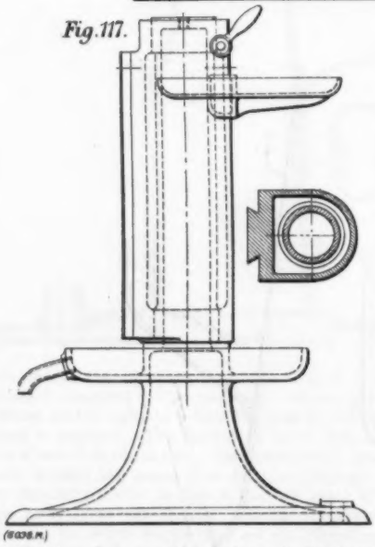


Fig. 118.

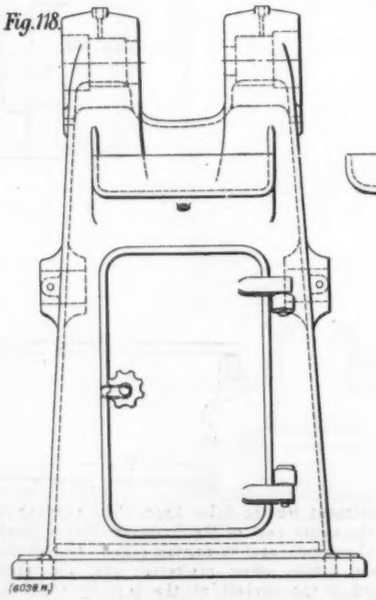
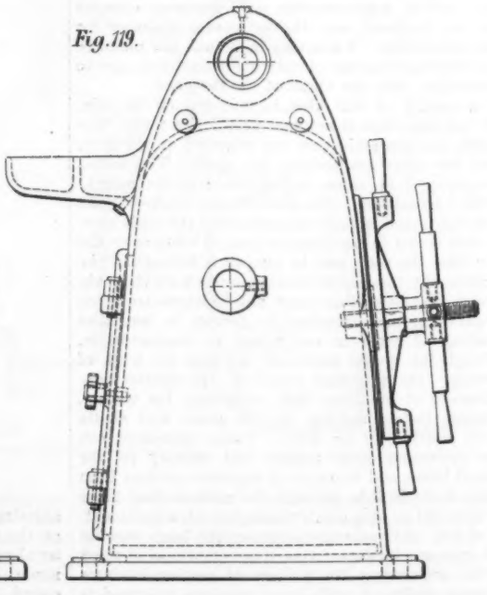


Fig. 119.



Figs. 111 to 113 afford an example of compact design, being a Richards' modified form of Lincoln miller. The framework of the bed, the horizontal, and the vertical slide-ways only include two castings of boxed forms, with much detail, and considerable coring. The base is utilised for the reception of the feed gears, which are mounted on the inside of the door, shown in Fig. 111. It is surrounded with a waste oil trough, that is extended with large radii to form a broad foot, with bosses for hold-down bolts. The base supports the upper frame, being extended underneath the vertical slideway, but terminating some distance short of the horizontal bed (compare Figs. 112 and 111). In the other view, Fig. 113, the width of the base coincides with that of the top casting, and a bead breaks joint. The vertical feed screw to the cutter head is enclosed and protected by the D-section of metal, Fig. 112.

A comparison of the framing in Fig. 110 for a pillar and knee machine, with Figs. 111 to 113 for a modified Lincoln miller, illustrates a record in evolution. The first was invented by Mr. Brown, of the firm of Brown and Sharpe, at a period when all milling was of a very light character and the milling cutter was not regarded as a possible future rival to the planer tools for heavy slogging. It was also from the first a universal machine on which, to the work of light, plain milling was superadded that of fluting taps and reamers, and the cutters themselves. It was employed for cutting gear wheels—spurs, bevels, screw and worm gears—for which index centres, and a universal head were essential portions of the equipment.

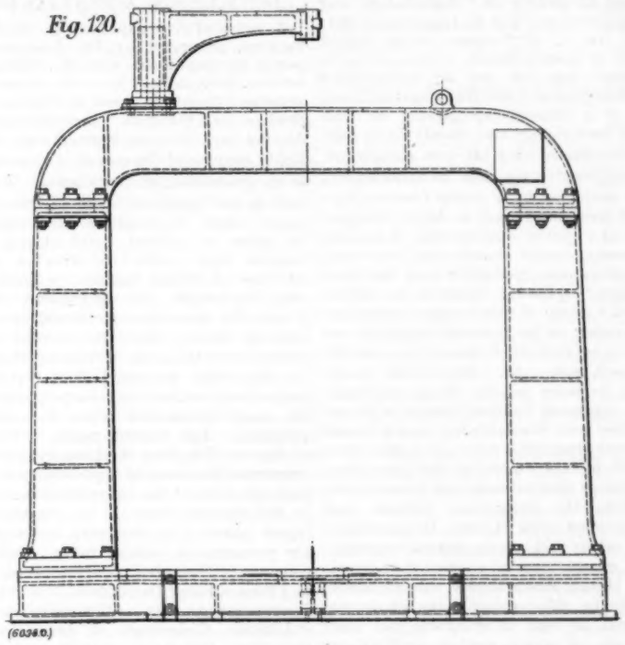
Not until heavy work was attempted did the weakness of the cantilever knee design, and the overhang of the arbor support become painfully apparent. Then followed the design of more substantial framings, the addition of supporting screws, the fitting of bracings, and later the separation of a group of plain massive "manufacturing" machines, distinct from those provided for universal functions.

One advantage claimed on behalf of the pillar design is that the unobstructed area round the knee allows the workman to see and handle his tasks readily. The work is always in view, because it moves laterally; in the Lincoln design it moves away, behind the cutter. Nevertheless, as a manufacturing machine, when plain, heavy milling is required, the Lincoln design is preferred. The work table is supported either on a stiff bed, or on a base, and the cutter spindle is supported equally at each end on head and tailstocks, on which vertical adjustments are made, instead of imparting these movements to a work-supporting knee.

The illustration, Figs. 111 to 113, differs from the general standard form, not in essential construction, but in the modification which permits it to be used as a Lincoln machine, or, on the removal of the tailstock—the upright movable member, which is not shown—as a pillar machine. Later, the Lincoln design merges into the plano-miller, in which work far beyond the capacity of the first-named is handled, a machine which now rivals the planer, both in quantity of output and accuracy of results.

Slotting machines.—Fig. 114 illustrates what may be regarded as the standard design of slotting machine framing, hardly modified in any detail through many years past. This is one of the frames that resembles those of punching machines in the character of the strain imposed on it, a sudden shock on the entrance of the cut, tending to cause a diagonal fracture through the upper portion, though probably this never happens to slotters. The strain, though of the same kind, is not so severe, because the area of the cut is less than that of a punch. But in all machines the slotting tool perceptibly springs and kicks back on starting to cut, and deep cutting and a long stroke combined are inconsistent with accurate results. Though this relates to the elasticity of the tool, some shock and bending stress must be transmitted to the frame, which requires therefore to be reasonably rigid.

Fig. 120.



(6036 O.)

The frame tapers upwards in this view, and also in the end elevation, not included, which form corresponds with the condition required in a cantilever. The metal only averages ⅜ in. thick, which, however, renders the broad areas rigid enough. The cone pulleys are carried between the arm at the right hand and the body. The feed disc for the table is enclosed in the small opening in the upper part of the frame, and the gap to the left of that next the ram slide receives the quick return disc. The ram moves in vee'd ways, and the table slides on the extended base. Patterns for frames of this class are made by boxing-up, and the moulds are cored. A single core suffices, with a print on the base, the pattern moulding on its side.

A curious relic of the past is the early slotting machine, Fig. 115, about 73 years old, by Caird and Co., a Greenock firm of that period. The fluted column and the architrave were in harmony with the ideas of that time, and architectural embellishment was carried to greater extremes in America than in Britain. This odd redundancy apart, the machine is in its essential movements similar to many built to-day. It has the geared crank-drive to the ram, but without quick return. The length of stroke is adjustable. A fly-wheel acts as an equaliser. The table has compound and circular movements by hand, and it tilts for angular slotting, as required for cutting keyways.

Fig. 116 shows another reminder of the past—the front view of an early Whitworth slotting machine, which is at least 78 years old. In some sketches of Swindon works made in 1842 this machine appears, slotting out a locomotive crank. The bridged design was adopted in order to avoid the obstruction to work from front to back that occurs in the single-column design. The ram moved in guides in the centre of the cross girders. It was, in this machine, driven with a screw, from belt pulleys above, transmitting the motion through reversing bevel gears, but without quick return, a method precisely like that adopted in many of the Whitworth planing machines of that and long subsequent periods. The rotation of the screw was communicated to the ram through the two flanking "anti-friction rollers" seen in the broken section, which entered into the grooves of the screw. Their spindles were carried in brackets on the ram. The machine was entirely self-acting. A stop-rod, seen to the right of the ram, with its stops set to the length of stroke, when moved by the ram, shifted a bell-crank lever that moved the belt-guide over for driving, or reversing. A short rack on the stop bar meshed with a pinion on the axis of a weighted lever which was pinned to a cam that communicated motion to the series of levers seen, whence through mitre gears the table movements were actuated.

Cutter-grinders.—The cylindrical column form of support is favoured for the small cutter-grinding machines. Fig. 117 shows one of the A. Herbert designs. The base is circular, with a waste lubricant trough. In some later machines the base is continued from the diameter of the trough downwards. A cylindrical column is continued from the base upwards to support a sleeve that swings around the column, and which is graduated at the top. As shown by the cross-section to the right, the sleeve is made of D-section, with vee'd guide ways to receive a knee that slides vertically, to be clamped in any position, and on which the work-tables are carried. Through the swinging movement, grinding wheels which have their bearings on top of the central column, can be brought into operation, and cup and disc wheels can be used with the spindle parallel with the work, or at any angle up to 90 deg. A tool tray is seen attached to the hinder part of the sleeve. This cylindrical design is general on light cutter-grinding machines. The mutual fitting is easily done, and the wear, owing to the large surfaces in contact, is negligible. The column and its sleeve afford ample support under the light duties imposed, so that the effect of overhang of the knee and the table slides is not perceptible.

Disc grinders.—A compact design, Figs. 118, 119, of framing for a double-ended disc grinder, is by Messrs. A. Harper, Sons and Bean, Limited. With metal averaging only from ½ in. to ⅝ in. thick, a very stiff casting, boxed-up to the spindle bearings, is produced. The large interior is utilised as a cupboard, with a wood floor, which is carried on a return flange in the base. The cupboard is closed by a door. The cementing disc is conveniently stored on a facing on the side opposite to the door. A combined water and tool tray with a dividing partition is cast with the main framing. Though recent, when compared with the machines that use solid wheels, the disc-grinders have won popularity, and by the help of excellent table fittings, and provisions for fine adjustments, they take rank with the precision machines. Cylindrical column supports would not be suitable for these. The framing shown corresponds with the severe vibratory stresses that are transmitted from discs of large diameters. The tapering outlines extend in both directions to the fullest extent permitted by the proximity of the tables and their fittings, and the discs. A broad, squat, most rigid support is embodied. The bearings are solid to receive ball bearings for the spindle.

Vertical boring machines.—A front view of the framing of a heavy vertical cylinder-boring machine by Messrs. Hulse and Co., Limited, is shown by Fig. 120. The built-up, arched structure is carried on a base provided with tee-grooves through which the cylinder flanges are bolted down. The boring

bar is rotated in the boss in the horizontal member of the arch. Facings carry brackets for belt cones, for the worm gear drive for effecting the rotation of the boring bar, and of the gears for feeding the cutter-head. The example affords a good study in box design. The frame would be too unwieldy, though not impossible, to cast in one piece, but it is better made in three, as shown, united with six bolts at each horizontal joint. The castings are flanged here at front and back, with thickening bosses for the bolts. In the end elevation, not given, the width of the framing is about double that seen in the front view. And in addition to being splayed from above downwards, it is cast with a continuous central web, reinforced with stiffening ribs, like those seen in the front view, Fig. 120. In this way the enormous twisting stresses that are set up in boring large cylinders are resisted. A few leading dimensions will give an idea of the proportions of the framing. It measures 10 ft. clear between the uprights, and 10 ft. from the top of the base casting to the underside of the arch. The feet of the uprights measure 2 ft. 5½ in. in the view given, by 6 ft. 4 in. in the other direction.

THE BRITISH ASSOCIATION.

(*Concluded from page 543.*)

SECTION B.—CHEMISTRY.

Metallurgy during the War.

In the first part of his paper on "Metallurgy during the War," Professor Cecil H. Desch dealt particularly with the expansion of the German iron industry since 1871, the importance of the occupation of the French iron districts during the war, and the serious difficulties to which German metallurgy had soon been reduced by the blockade. Dr. Desch suggested that, with the increasing German production of iron and steel, and the difficulties of finding raw material and new markets, a crisis in metallurgy and in industry generally had been approaching before the war, and that it had some influence in determining German policy. The peace of 1871 had left France with more than half the Lorraine iron ore, the rest being in German and, to a small extent, in Luxemburg and Belgian territory.

The pure non-phosphoric ore of the Anmetz district was soon worked out, but the Thomas-Gilchrist basic process made the minette ore available for the steel industry. By 1913 21,000,000 tons, out of a total of 28·8 million tons of the German iron ore output, came from German Lorraine. In January, 1914, an agreement was made between French and German ironmasters to start works in Caen (Normandy) with local ore and Westphalian coal. The war put an end to operations in many Lorraine works, both on the French and the German sides. France made remarkable progress in enlarging and restarting iron works, notably in the regions of St. Etienne, Firminy and Rouen. In Germany the production of iron and steel fell off, but rose again to the pre-war level by the end of 1916. Later it seems to have decreased again, owing to the want of labour and raw materials. Passing to the dearth of other metals in Germany (with which we have dealt on other occasions), Dr. Desch remarked that though the scarcity of manganese had not stopped the war by the end of 1915, as some writers over here had expected, the substitution of calcium carbide for manganese, as deoxidiser of iron, had not been satisfactory, and shell makers had had to depend chiefly on low-grade manganese ores. The dearth of copper, in which the Allies had permanently a strong position, had been far more serious, though zinc, iron and aluminium had been made to serve as substitutes.

The great advances made over here in the manufacture of tungsten and alloy steels were well known. It was not correct to ascribe the loss of the zinc industry (notably that of Australia) to the apathy of the Government; the mine-owners and smelters must share the blame. They had not devoted so much attention to the complex problems of Broken Hill ores as German metallurgists had done. The shortage of Spanish iron ores had been met by the smelting of the jurassic phosphoric iron stones of Lincolnshire, Northamptonshire and Oxfordshire. The slag difficulties had been overcome by physico-chemical studies. Brass and cupro-nickel had been much improved; extrusion was largely used for making the rods. Cast iron had been used as a substitute for brass in fuse bodies. Similar experiments with white alloys had been less successful. Aluminium alloys had come into extensive use, thanks to research, and with a continuance in the interest in science shown recently the British metallurgical industries should retain and even improve their present leading position.

During the discussion Mr. Cosmo Johns confirmed Dr. Desch as to the value of calcium carbide as deoxidiser of steel; sometimes 30 per cent. of the shell bars so produced had had to be scrapped. Though the Germans had not made any metallurgical advance during the war, it was marvellous that they had been able to struggle on so long, considering the shortage of everything and the breakdown of transport owing to the want of lubricants and bearing metal.

Bacteriology and its Practical Applications.

In introducing his lecture on "Bacteriology and its Practical Applications, and its Importance Outside Medicine," Dr. A. C. Thaysen, of the Naval Cordite Factory at Holton Heath, expressed regret that bacteriology was not yet an independent science. The bacteriologist was still a medical man, or a chemist or a botanist, specialising in some small branch of bacteriology and classifying and describing the phenomena from his own standpoint. Thus it had been possible, *e.g.*, that an abnormality, described as a mutation by a young German bacteriologist, had been understood to denote the permanent change of a quality characteristic of animals or plants possessing sexual reproduction, the sense in which botanists and geologists used the term mutation. Strictly speaking bacteria or schizomycetes formed a group of microscopic, unicellular organisms, belonging to the vegetable kingdom and living parasitic or saprophytic in animal or vegetable tissue, in the soil, water, &c. Moulds and yeasts were generally included in the group, however. Bacteria might represent the first bearers of life on our planet. They were domesticated (in the leaven of the bread) more than 2,000 years ago; they were first seen in 1683, but not studied till 200 years later, and though Pasteur first investigated fermentation and putrefaction, the pathogenic bacteria had claimed chief interest until Hansen, Winogradsky, Beijerinck and others took up the general industrial problems. As regards power alcohol the experiments made at Holton Heath showed that reclaimed heathland would be able to supply the whole raw material required, 24 tons of mangolds (per acre) yielding 240 gals. of power alcohol, and intense heath cultivation would bring other benefits. That the vinegar production was due to a micro-organism had been proved by Kützing in 1838, but the methods of vinegar manufacture were still unsatisfactory. Some of the acetic acid bacteria oxidised the higher alcohols, *e.g.*, butyl alcohol to butyric acid, the esters of which were at present used for margarine flavouring only, but the alcohol and acid might find wider application.

The fermentation of carbohydrates into butyl alcohol and acetone had attracted much attention during the war here and abroad. One Admiralty plant was planned for 30 tons of acetone weekly with fermentation tanks of 150,000 gals. capacity for dealing with 35 tons of raw material in one fermentation of 35 hours. The exclusion of foreign bacteria before and during fermentation and the sterilisation of the liquor had proved very difficult. Two lactic acid bacteria in particular had refused to be killed by the usually recommended exposure to 100 deg. C. for a short time. Boiling of the mash for 36 hours had failed. In autoclaves of 8,000 gals. at 130 deg. C. the one organism had survived after two hours, and had only been destroyed after six or eight hours. Then, however, the conversion had proceeded quite satisfactorily. It was observed that acetic acid appeared and disappeared again during this fermentation, and any acetic acid added to the fermenting liquid, it was discovered, was converted into acetone. Even in large-scale experiments 80 per cent. of this added acid passed into acetone. This new method of manufacturing acetone was thus far more efficient than the distillation of calcium acetate. The simliar manufacture of lactic acid (carried out in America and Germany for 20 years) and of citric acid (not quite worked out yet technically) were also promising.

Dr. Thaysen passed to the great importance of bacteria in dairying and in the soil (fixation of nitrogen, humus formation) and in sewage disposal, also in the retting of flax, the flavouring of tobacco, cocoa and mocha coffee, in tanning and in the cotton industry. This last problem is being investigated by Dr. Thaysen. Bacteria were responsible for the destruction of up to 15 per cent. of some cotton crops, he said; the danger began as soon as the boll opened, but only in the presence of moisture. When the moisture exceeded 10 per cent. serious damage was done in less than a week. Some bacteria cut the fibre up into sections, others destroyed the cuticle and ate their way gradually through the cellulose. In his conclusion Dr. Thaysen returned to the theoretical aspects of the problems and their bearing upon the heredity questions of higher forms of life.

Butyl-Alcohol, Acetone and Distillation.

A series of five papers from the Naval Cordite Factory, presented by Dr. Joseph Reilly, M.A., partly in conjunction with Mr. Wilfred J. Hickinbottom, dealt more or less with the chemistry of the acetone fermentation and of bodies related to explosives. In the first, "Mechanism of the *n*-Butyl Alcohol and Acetone Fermentation Process," Dr. Reilly mentioned the names of some of the bacteria used—granulobacter butylicum, bacillus amylobacter, and tyrothrix tenuis. From 100 grams of maize might be produced 7 grams of acetone, 16 grams of normal butyl alcohol, 2 grams of volatile fatty acids, 16 litres of hydrogen and 19 litres of carbon dioxide; a little ethyl alcohol was also formed. In the presence of calcium carbonate the two acids—acetic and butyric—were the main products; the butyl alcohol seemed to be formed from the acid. Professor Morgan, who was in the chair, remarked that butyl alcohol, at present a rarity, had valuable properties which would be more appreciated when the alcohol became plentiful. The second paper, "The Distillation of Aqueous Solutions of related Organic Substances," concerned the range of applicability of Nernst's law, that the ratio of the concentration of a constituent in the vapour phase to its concentration in the liquid phase is a constant, and the influence of the presence of various other substances on this constant. The other papers were on "Arylamines and their *n*-Butyl Derivatives," on "Intramolecular Rearrangement of Alkylarylamines," and on "Addition Compounds of Aromatic Amines and their Nitro-Derivatives with Metallic Salts."

We should add that, after the reading of the various war papers, the Section passed a resolution—against several dissentients—emphasising the desirability of continuing systematic researches on explosives and other military matters. Sir W. J. Pope urged this resolution, and Professor A. Gray, in seconding it, remarked that the scrapping of the Inventions Board would be false economy.

Chemical Reactivity.

The first of these papers, on chemical reactivity and valency, was by Professor E. C. C. Baly, F.R.S., of Liverpool, on "The Molecular Phase Hypothesis, a Theory of Chemical Reactivity." The new views advanced are an outcome of Professor Baly's studies of light absorption, especially in the infra red, to which we have referred on other occasions. As ordinarily seen, Professor Baly pointed out, absorption bands were indistinct, and the curves of absorptive power (plotted against frequency) rose to rounded-off peaks. When the substances were cooled in liquid air or hydrogen, the curves narrowed down and were seen to consist of series of secondary peaks culminating in the line of maximum absorptive power. That line marked the characteristic frequency, and there were constant frequency differences between the secondary peaks of a group. The frequencies of the bands or lines so resolved represented multiples of some fundamental frequency in the infra red, and each element had one or several characteristic frequencies. When two elements combined, the characteristic frequency of the compound was the least common multiple of the frequencies of the constituent. That could be

accounted for on the quantum theory. Energy was lost by the combination of A and B, and if A had the characteristic frequency 5, B the frequency 7, then the emission of energy (and also its absorption) would occur in energy quanta of $5 \times 7 = 35\ h$ (where h was Planck's constant. To understand the mechanism, we might regard the simple atom as something resembling a Saturn system, a nucleus surrounded by a ring of electrons; the whole represented a field of electromagnetic force, the lines of force passing through the ring. In groups of atoms the fields might be symmetrical or not; similar or opposite poles would face one another, and the resulting field of force might hence be closed or open; the lines of force might be imagined to be closed (upon themselves) even in a single atom. The fields were opened up by chemical activation. Reactivity now depended upon the disposition of the field; the closed system would not display reactivity, and the molecules of a system might be in different phases, which would account for the varieties of modifications in complex molecules, in sulphur, *e.g.* Valency was a measure of the number of characteristic frequencies. Professor Baly further referred to the group properties of the alkali metals, to catalytic action and to ionisation from his point of view.

The other two papers, by Professor A. Lapworth, F.R.S., of Manchester, on "Latent Polarities in the Molecule and the Mechanism of Reaction, with special reference to Carbonyl Compounds," and by Professor R. Robinson, D.Sc., of Liverpool, on "Conjugation of Partial Valencies," were both presented by Professor Robinson.

Fuel Economy.

The second report of the Committee on Fuel Economy (chairman, Professor A. W. Bone, F.R.S.; secretary, Mr. R. Mond, M.A.), read in abstract by the secretary, consisted of several parts. The first part outlined the work of the Committee since 1916 when, mainly on its instigation, the Fuel Conservation Committee was established under Lord Haldane. When, later, the Research Department and the Committee disagreed as to lines of research, the Committee suspended its work, but resumed it in October, 1918. The Committee was then reduced to 30 members (45 previously) and was reorganised in three sub-committees—Chemical and Statistical, Carbonisation and Metallurgical, Power—under separate chairmen, and the co-operation of the interested societies and institutions was secured. The second part dealt with Coal Outputs and Prices since 1913. It pointed out that the chief raw materials produced in the country above its own requirements were coal, clay and salt, and of the most important of these, coal, we exported in 1913, 97·5 million tons; on the other hand, half of 10·5 million tons of iron ore smelted were imported, as well as 95 per cent. of the zinc, 90 per cent. of the lead, and 80 per cent. of the wood and timber, in addition to 257,000,000*l.* worth of food, drink and tobacco. With respect to the outputs of coal and the average pithead prices (Table A) and the prices per ton paid by consumers in Great Britain (Table B), the following statistics were given:—

Table A.—*Output of Coal in Great Britain.*

Year.	Output in Million Tons.	Output in Tons per Person Employed.	Average Pithead Price per Ton.
			s. *d.*
1913	287·4	260	10 1
1914	265·6	238	10 0
1915	253·2	270	12 6
1916	256·3	260	15 7
1917	245·0	247	16 9
1918	227·7	232	24 0

Table B.—*Price of Coal per Ton to Consumers.*

Year.	I.	II.		III.
		a.	*b.*	
	s. *d.*	*s.* *d.*	*s.* *d.*	*s.* *d.*
1914	29 0	11 2	14 6	12 0
1915	34 8	15 5	22 11	16 2
1916	37 0	16 5	26 4	22 3
1917	38 0	16 8	32 5	22 10
1918	44 0	20 11	34 4	24 5

In Table B, column I refers to price of best house coal delivered in London, column II to the price of gas coal of the South Metropolitan Gas Company (*a*) f.o.b. at North-East Coast, (*b*) cost into works, and column III refers to Durham coking coal at a Cleveland iron works. While prices were still rising, the annual output per worker employed in British mines had steadily declined, and that had been going on for thirty years, these outputs for the decades ending 1892, 1902, 1912 being respectively 320,000,000 tons, 295,000,000 tons, 290,000,000 tons. But in Germany, and particularly in the United States, the annual outputs per worker had increased as Table C, triennial periods, indicated; and this increase of total output (Table D, column I) and of output per worker (Table D, column II) had continued in the United States during the war.

Table C.—*Coal Output per Worker per Annum.*

Year.	Great Britain.	Germany.	United States.
	tons.	tons.	tons.
1905–7	289	248	589
1908–10	265	239	591
1911–13	254	263	651

Table D.—*Coal Output per Worker per Annum in U.S.*

Year.	I.	II.
	million tons.	tons.
1913	508·9	681
1914	458·5	601
1915	474·6	647
1916	526·9	732
1917	581·7	768

Thus in 1917 the American coal output per worker was more than three times that realised in British mines, and the coal and coke prices had in America risen to a maximum about the middle of 1917, and had dropped afterwards; the statistics given in the report varied considerably, however; stove anthracite keeping fairly steady up to 1917, had in fact risen since, from 23*s.* 5*d.* in 1917 to 27*s.* 1*d.* in 1918.

The third part, on Coal Research, stated that the recent experiments by Bone and Sarjant, and by others, made it very doubtful whether the resinous and cellulose constituents of coal could really be separated by the aid of pyridine and chloroform, used by Wheeler and others. It would appear that pyridine affected the coal substance as a whole, especially at higher temperatures and pressures, whilst the presence of water and oxygen retarded this action. In 1916 the Committee had recommended that the resources of all existing laboratories should be utilised for coal research; the present report, again, wished to impress upon the public and the Department of Scientific and Industrial Research the dangers of sterilising fuel research by a policy of over-centralisation of research.

After brief references to Fuel Consumption in the Iron and Steel Industries and on Electric Power Supply, the report passed on to its last important subject, Future Standards of Public Gas Supply. As to this the Committee dissents from several of the recommendations contained in the report of the Fuel Research Board of January, 1919. Some of those recommendations were: The consumer should be charged according to the thermal units received by him, the gas value being considered proportional to the calorific power; that, subject to a maximum limit of 12 per cent. of inert constituents, the gas undertaking should be at liberty to fix the calorific value of the gas supplied, though there should be a standardisation to four grades of 400, 433, 466, 500 British thermal units per cubic foot; that sulphur and cyanogen should more completely be removed; and that under normal conditions the gas pressure at the consumer's meter outlet should not be less than 2 in. of water. The Committee agrees that the consumer should be supplied with a suitable gas for lighting and heating, while the recovery of by-products should be secured in the general interest. It would not exclude the distribution of surplus coke-oven gas through the public mains, or the steaming of incandescent coke in continuous vertical-retort working; but it would not oblige a gas company to convert all its coke into water gas. The Fuel Board recommended water gas as natural diluent. As regards the calories mentioned, the following figures were averages of 1913 of six of the largest cities: 620, 596, 593, 582, 582, 540 B.T.U. High-temperature carbonisation in modern vertical retorts yielded a gas of the average percentages: CO_2 2·5, CO 7·5, $C_n H_m$ 3, CH_4 30, H_2 50, N_2 7, and of 560 B.T.U. gross and 495 net; debenzolised coke-oven gas (with 25 per cent. of CH_4) gave 485 and 425 B.T.U. As the thermal efficiency of that carbonisation was admittedly high (83 per cent., *e.g.*, in 1913) there seemed to be no reason for superseding the practice of 1913. Water gas had the average composition: CO_2 4·5, CO 43, H_2 48, CH_4 0·5, N_2 4 per cent., and gave 300 and 275 B.T.U., gross and net; it could be made from coke with a thermal efficiency of 70 per cent., its calorific intensity was high, but the CO percentage made it dangerous, and owing to the high hydrogen and the low methene content it was very liable to backfire. The old maximum limit of 20 per cent. of permissible CO should not be exceeded. The Committee could not admit that the relative value of a grade of gas was simply proportional to its calorific value. The composition of the gas was not an indifferent matter to the consumer; in particular the percentage of CH_4 should not be reduced below 30. To strip the gas of benzenoid hydrocarbons seemed inadvisable if the thermal basis were to be adopted. As regards the removal of sulphur (other than H_2S) and cyanogen, Mr. D. H. Helps (representing the Institution of Gas Engineers) disagreed from the Committee and the Board; he would not impose any conditions as to the gas composition, and considered a minimum gas pressure of 1½ in. sufficient.

During the discussion of the report Sir Robert Hadfield (chairman of the Metallurgical Sub-Committee) remarked that he had been impressed by the arrangements made for economical use of coal in Germany, and by the waste of coal in America; we had to face a serious shortage, but the men were willing to co-operate in economy when the matter was clearly put to them. The problems would come before the Iron and Steel Institute, and the Federation of British Industries. Mr. C. E. Stromeyer regretted that the report said so little on the power question; steam was more economical generally than water power; electric power was advantageous in shipyards, &c., where heavy machinery was in use at intervals; for continuous use steam was preferable, and some of the figures that had been published on the possibilities of large electric power schemes were misleading. Mr. Arnold Lupton agreed on this point, though he was not against electric power schemes and not alarmed about the exhaustion of the British coal stores. He would certainly limit the CO percentage, but he was against restriction of working hours, which should be left to the employers and employed. Mr. Golden supported Mr. Helps; it was impossible to work to a stipulated gas composition; sulphur in the usual percentages was harmless and, in fact, germicidal, cyanogen was also harmless; in the cases of CO poisoning, of which Mr. Lupton had spoken, the CO must have had a special source. Sir Charles Parsons said that the large experimental station of the Fuel Research Board—which would welcome criticism—was approaching completion and would first devote itself to the carbonisation problem. He agreed that electricity could not compete with steam in works (breweries, paper mills, &c.) where much heating was required; there inefficient steam engines might answer, as the exhaust could be utilised; the day for the large internal-combustion engine had not yet come, except where low-grade coal had to be used; the modern steam turbine had nearly as low a fuel consumption as a gas engine and gave clean steam, free from oil.

Professor W. H. Watkinson (Liverpool) said that the figures about British and American outputs required explanation — the report had not explained these figures; he concurred that all available laboratories should engage in coal research, and that provision should be made for the free circulation of the results, as was done in America. Professor H. E. Armstrong thought that the work of the Fuel Research Board should be conducted more openly, and that conferences be held from time to time. The constitution of the gas was certainly important, and sulphur not harmless. Lord Fisher

wanted oil fuel for the Navy; but America told us that she would have no oil left in twenty-five years; we should hardly find oil in this country, and would have to get it from coal. The present gas industry would have to reform its methods of manufacture; gas production and power generation must be combined; a smokeless solid fuel and a high-quality gas, that would bear dilution, could be obtained at the same time.

Concluding Remarks.

Though we cannot deal with the proceedings of the other sections, except in special articles, it will be seen that the revival of the British Association meetings was fully justified. The attendance figure of 1,471 members was very satisfactory, and the grants of 1,133*l.* came up to the pre-war average again. Of this sum the largest portion (450*l.*) as usual went to committees of Section A (100*l.* for seismology, 150*l.* for tidal observations, 40*l.* for tables of physical constants, 50*l.* for radiotelegraphy); Section G received 80*l.* for complex-stress research. The total of the grants and the fact that the Committee of Recommendations had to meet in solemn conclave to allot the quota, have been sneered at. The meeting itself has been derided as a gathering of 1,500 people, including quite a number of scientific men, attracted by Bournemouth, the summer weather, the expected revelation of war secrets, and excursions with a decent scientific pretext. Such criticisms are as old as the popularity of the Association, and old members will admit that there is some substance in them without being in the least shaken in their deep attachment to the British Association. The Association does not make big grants, because it has no big funds to dispose of. The allowance of a few pounds—for correspondence, &c.—to a committee may appear petty; the point is that a committee has been created with authority to approach the proper people for joint action. The critics will not deny that great things have grown out of British Association Committees'; new lines, among them the revision of county maps and the unification of the nomenclature, are being taken up, and it is largely the committee work, the nucleus activity, about which little becomes known, that appeals to the Dominions. The subdivision into 12 sections is regrettable in some respects. The foundation, in 1912, of the twelfth section, M. Agriculture, may possibly have been a mistake, and subjects discussed at Bournemouth such as international rivers, hypnotic treatment of shell shock, and legal enactment of a working day, may only have a remote connection with science. But fatigue certainly is a scientific subject, and who is to draw the dividing line? The essence of the Association is that it brings scientists of all branches together. If the critics would like to impose some qualification test or the possession of a degree on members, so as to separate the camp-follower from the scientist, we should certainly disagree.

Next year the British Association is to assemble in Cardiff under the presidency of Professor W. A. Herdman, F.R.S., of Liverpool, whose acceptance of the honour involves his resignation from the office, he held so far, of senior general secretary. Professor H. H. Turner succeeds him in this dignity, and Professor J. L. Myres, F.R.S., has been elected to fill the vacancy thus created. The Cardiff meeting will again be a short one, Tuesday to Saturday. It is a pity; for there will be little time for visiting the works which will be thrown open to members. As Cardiff desired this arrangement, however, there is nothing to be said. But we are glad that in 1921, at Edinburgh, the full week meetings, Wednesday to Wednesday, are to be resumed.

GAS ENGINES DRIVING ELECTRIC GENERATORS AND BLOWERS.

In recent issues we have given particulars of Diesel engines made during the war by Messrs. Vickers Limited at Barrow-in-Furness. In our present issue, we publish several illustrations of large horizontal gas engines undertaken by this firm. The engines illustrated are from a batch of eight ordered by Messrs. Appleby Iron Company, Limited, of Frodingham and Scunthorpe, Lincolnshire, delivery of which began some months ago, and is now nearing completion. The first engine, which drives a direct-current generator, is being installed at Frodingham, while the remaining seven engines, five driving Metropolitan-Vickers Electrical Company's 3-phase, 50-cycles, 6,600-volts A.C. generators, and two driving blowing tubs, are for use at Appleby, Lincolnshire. Such an undertaking is interesting evidence of the wide-spread activities in the internal-combustion business of the Vickers' concern. Their experience in the manufacture of Diesel engines, including the largest unit in this country, has stood the firm in good stead with these large gas engines, while their great resources for forging, casting and heavy machining render them peculiarly competent to undertake such work.

On the two-page plate accompanying this issue, and on the present page we give several views of the engine for driving the electric generator, while on page 577 there are two views of the engines for driving the blowers. Fig. 1, on Plate XXXII, is a front view of the engine for driving the generators, completed in the erecting bay of Messrs. Vickers' works, while Fig. 2 is a view to a larger scale of the cylinders of the same engine. This view clearly shows the valve gear, the exhaust valves placed under the cylinders, the air-starting levers in the centre above the camshaft, as well as the sight-feed lubricators for the piston and piston rods. Fig. 3, also on the two-page plate, is a view from the forward end, showing the flywheel. In this view the man standing in the foreground gives by comparison a fair idea of the size of the engine.

Fig. 4, on Plate XXXII, is a view of the connecting rod on end, and a comparison between the workman, and this unit of the engine again affords indication of the proportions of this prime mover. Fig. 5 on the present page is a view from the rear end. This view shows the ignition distributor and the adjusting gear on the end of the 2 : 1 shaft. The views on page 577, as we have already stated, represent one of the engines built for driving the blowing cylinders at the Appleby Iron Works, Fig. 6 being from the forward end and Fig. 7 from the rear end.

The engines, as will be observed from the engravings, are of the tandem, double-acting four-stroke cycle type. The diameter of the cylinders is 1,100 mm., the stroke being 1,200 mm., separate liners being fitted. The speed of the generating sets is 100 r.p.m., at which speed an output of 1,200 kw. is obtained, but for blowing purposes the speed is reduced to 80 r.p.m., at which the output is 27,000 cub. ft. of free air per minute delivered against a pressure of 12·5 lb. per square inch, while arrangements are provided whereby this pressure can be considerably raised in case of need. The blowing cylinder is 95-in. bore, and is clearly shown in Figs. 6 and 7.

GAS ENGINE FOR APPLEBY IRON WORKS.

CONSTRUCTED BY MESSRS. VICKERS, LIMITED, BARROW-IN-FURNESS.

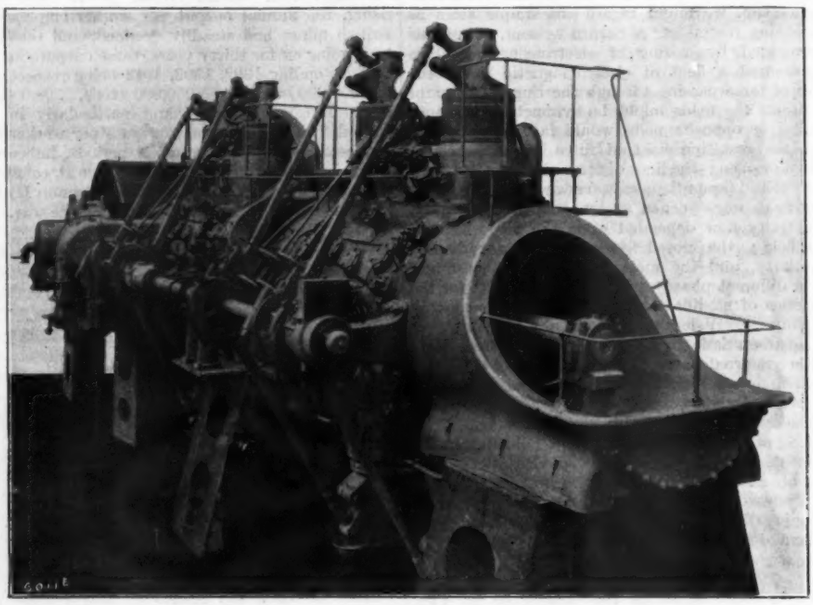


Fig. 5. View from Rear End showing Ignition Distributor.

The general arrangement of the engine, it will be observed, follows on the more or less accepted lines of the most successful Continental types, but in details Messrs. Vickers have, in collaboration with the purchasers, made a number of improvements to overcome difficulties or trouble experienced by users in this country or anticipated by themselves as a result of their internal-combustion engine experience. Particular attention has been paid to the intermediate coupling of the piston rod, which in a number of the earlier engines gave considerable trouble. In addition, the design of the exhaust-valve boxes has been thoroughly overhauled. The engines are arranged for working on blast-furnace gas, but by making small adjustments they can be run on other gases, such as producer or coke-oven gas.

The crankshaft, a one-piece forging weighing 20 tons, is provided with separate balance weights, the method of securing which has received special attention. The main bearings are 21 in. diameter, and the four-part brasses are lined with white metal and provided with self-aligning wedge adjustment. The outer bearing is also self-aligning, the brasses being provided with a spherical seat.

Lubrication of the main bearings, crankpin, main crosshead and slipper is carried out by gravity from an overhead tank at a pressure of about 5 lb. per square inch, splash guards being provided round each slipper guide to retain the oil and distribute it over the guide surfaces. All other important working parts are supplied with forced lubrication by adjustable sight-feed mechanical lubricators, which are situated on the intermediate portion of the bedplate, and can be seen in Fig. 2.

The piston rods are 10·75 in. diameter and made of 40-tons steel, each rod being accurately finished by grinding. They are hollow and convey the cooling water to the pistons. These rods are ground on two centres, so that when the weight of the piston is imposed, the rods are practically free from camber. The piston-rod glands are packed with a number of cast-iron rings, split into three parts and

GAS ENGINE AND BLOWER FOR THE APPLEBY WORKS OF THE APPLEBY IRON CO., LTD.

CONSTRUCTED BY MESSRS. VICKERS, LIMITED, ENGINEERS, BARROW-IN-FURNESS.

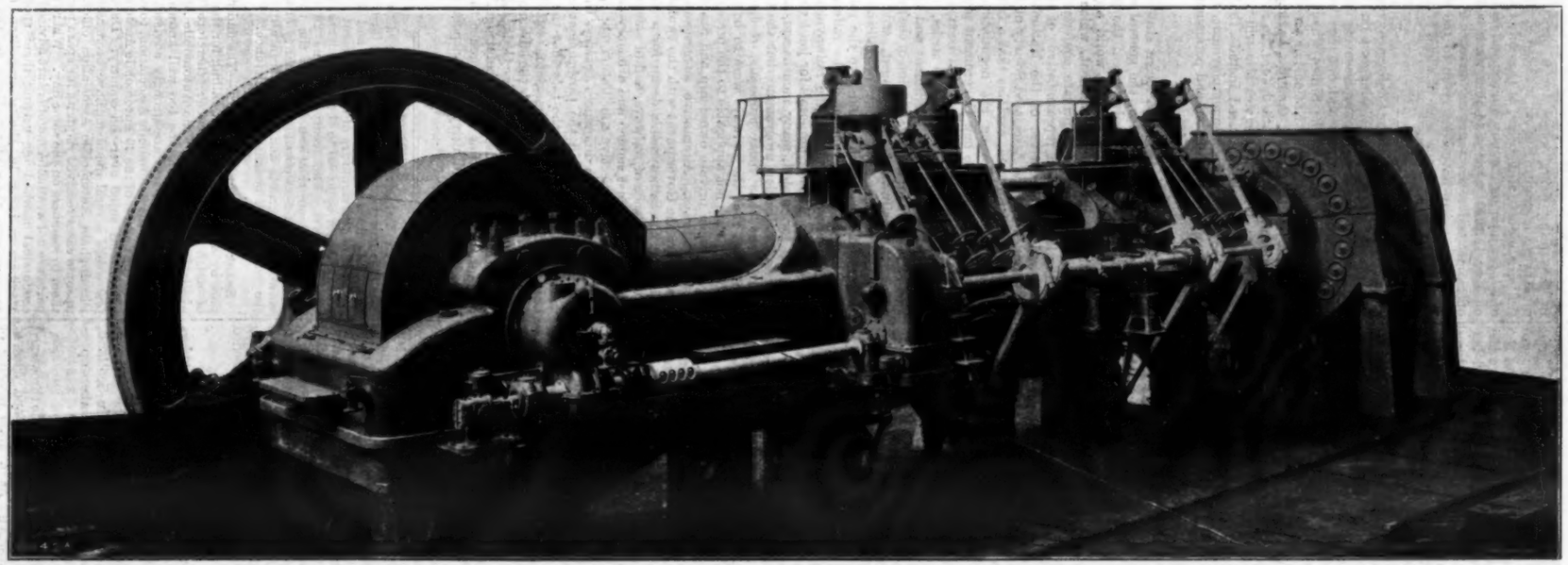


Fig. 6 View of Forward End.

Fig. 7. View of Rear End.

held to the rod by springs which surround them. Three white metal rings of a similar type are fitted at the outer end and the gland, as a whole, is under forced lubrication.

The inlet and exhaust valves are operated by shaped rolling levers driven by eccentrics on the half-speed shaft and eccentric rods, the valves themselves having cast-iron heads on steel spindles.

Governing is on the "quantity and quality" system, all important parts of the governor gear being carried on ball-bearings, thereby reducing friction to a minimum. The governor fitted is of a powerful type, and has hand adjustment allowing variation in speed either way. Separate hand control for gas and air for each end of both cylinders is provided for use when starting or when the blowing engine is required to run at reduced speed and output.

The ignition is effected by means of two low-tension "make-and-break" ignition plugs in each end of each cylinder. The current is supplied from a motor generator delivering current at a voltage of 70 volts, which is distributed by a rotary wiper. This, with its switches and timing adjustment, is fitted at the rear end of the two-to-one shaft. High-tension ignition can readily be applied to the engines when such is preferred by the purchasers.

The alternator sets are provided with flywheels of 61·5 tons weight, cast in two parts, which are held together by shrink rings and bolts. The flange of the alternator rotor is bolted direct to the flywheel hub, which gives a very rigid construction at this point and reduces the possibility of oscillation between flywheel and rotor. The approximate total weight of the blowing engine is 305 tons, and it has an overall length, excluding flywheel, of nearly 74 ft.

In these days, when rising fuel prices and the general necessity of cheapness of production bring power costs under the closest scrutiny, the economy of the large slow-running four-stroke cycle gas-engine, with its proved reliability, is becoming more clearly recognised, and for many plants, especially in the steel industry, it is regarded as the only prime mover to cope with present-day conditions. In these circumstances, it is reassuring to find that the comparatively few manufacturers of such engines in this country are being increased in number by the addition of a firm of the standing of Messrs. Vickers Limited, and that this country is to that extent less dependent upon foreign makers for the supply of such important machinery.

INDUSTRIAL NOTES.

Lord Askwith, in a most pertinent letter published in *The Times* of Tuesday last, makes charges against our present system of Labour Exchanges and unemployment "doles" which will receive whole-hearted support from both employers and employed. He points out that the doles are responsible for the existence of large and ever-increasing numbers of State buildings and officials for distribution purposes, and that, by relieving both sides of their proper responsibilities in connection with unemployment, the existing arrangements tend rather to foster the evils of unemployment than to relieve them. Most of the best trade unions, he states, still rely upon their own efforts to find employment for their members, and, before the present system was inaugurated, the fact that each unemployed member was a drain upon the union funds was a direct incentive to all union members to keep their fellow-members in work. Employers, in Lord Askwith's opinion, are also encouraged by the system of Labour Exchanges to accept no responsibility for the continuance of employment in their industry. The present necessity for reducing national expenditure by all possible means, he considers, renders it imperative for each industry, by its associations, trade unions and councils, to establish the necessary simple organisations for dealing with the problem of unemployment, making the cost of such organisations a charge upon the industry and not upon the community. Lord Askwith would like to see the Labour Exchanges, with their huge army of officials, entirely swept away, and we have but little doubt that the majority of our readers will be in complete agreement with him.

Speaking at the Liverpool Chamber of Commerce on Monday last, Mr. Frank Hodges, the Secretary of the Miners' Federation, put the case for nationalisation of the coal mines from the point of view of the workers. He maintained that nationalisation along the lines indicated by the miners, and partially adopted by Mr. Justice Sankey in his Report, would result in increased production and decreased cost. It would be an essential part of a scientific scheme that central power generating systems should be set up, and that collieries in large areas should be grouped together to ensure economical administration. National ownership of the mines, he continued, was an essential condition to the effective co-operation of the men in the industry, but he wished to make it clear that nationalisation did not imply Government management: the management would be in the hands of the existing technical and manual staffs. Bureaucratic control, he admitted, would be worse than private ownership. He then urged that it was a safe assumption that, by a complete understanding between the technical and manual staffs responsible to the nation for the good governance and administration of the industry, they might develop in the workers a new character and social outlook. There would be a new orientation of ideas of the men in the industry to the rest of the country, accompanied by a desire to give the country the coal it required at the cheapest possible price. This anticipation of a psychological change in the workman was one of the outstanding points of the speech, and its elaboration brought out a denunciation of the possibility of the technical and manual staffs exploiting the industry for their own advantage, regardless of the requirements of the rest of the country. "That," Mr. Hodges said, "would be syndicalism, and I have as strong an objection to syndicalism, on account of its anti-social character, as I have to capitalism." In reply to a question asked, Mr. Hodges said that, in spite of the introduction, in the meantime, of the seven-hours day, the output of coal in September was 2·9 per cent. higher than in June. Within the mechanical and technical limitations imposed by the existing system (and five years' wear and tear of machinery had to be allowed for), the miners were doing their best.

No agreement has yet been reached in the moulders' strike, and the effect of the dispute, which is now in its sixth week, is becoming more and more serious. In spite of the prolonged stoppage in the foundries, most engineering works have managed to carry on so far, but those shops which are dependent upon castings must soon come to a standstill. A statement recently issued by the Engineering and National Employers' Federations explains that the strike is due to the action of three unions in insisting upon an immediate advance in wages, and the breaking of an agreement for the periodical review of wages by the Interim Court of Arbitration. Some 50 other unions in kindred trades are technically abiding by the agreement, but, in some cases, instructions have been issued to members not to work on castings produced by "black-leg" labour. They thus tacitly approve of the action of the foundry unions, a fact which is much to be regretted, as it considerably hampers employers' efforts to keep as many as possible of their men at work. At the moment the situation appears to be a complete deadlock, as the men, who are only receiving 14*s.* a week strike pay, show no signs of yielding, and employers are apparently equally obdurate. So far as we are aware, there have been no negotiations between the parties concerned since October 11, when a separate agreement between the employers and the executives of the three unions was provisionally accepted by both sides, but this was afterwards rejected by the men. It is greatly to be hoped that negotiations will be resumed and a settlement reached at the earliest possible moment, as a continuance of the existing state of affairs will be disastrous to the industry. *The Times* correspondent reports that in Sheffield last week end 9,000 men and 2,500 women were on the lists for unemployment "doles," and these figures, it should be noted, do not include the moulders on strike or other foundry workmen. A similar state of affairs exists at Newcastle, where the strike is seriously affecting the shipbuilding and engineering industries. Most urgent ship repairing work is greatly hampered. The Coventry motor car industry is not yet affected vitally, but some departments are closed, and there is difficulty in obtaining delivery of engines owing to the lack of castings needed for completion.

In the October report of the Associated Ironmoulders of Scotland, Mr. James Fulton, the general secretary, states that the income for the previous month was 2,950*l.*—an increase of 215*l.*—and the expenditure 2,948*l.*—an increase of 284*l.* Owing to the strike in England and the rain-water goods strike in Scotland, idle benefit was heavy. The total membership is 9,080, an increase on the month of 92.

According to the *Manchester Guardian*, the threatened strike in the building trade in the North and West of England has been averted. At a mass meeting of operatives held in the Free Trade Hall, Manchester, on Sunday last, the terms fixed by the National Conciliation Board on the previous Friday were agreed to with but few dissentients. Briefly, the results of the negotiations following upon the demand for an increase of 4*d.* per hour are the waiving of an agreement made in the spring fixing wages for a period of twelve months; the granting of an increase of 2*d.* per hour (in large industrial districts) at the end of this month, of 3*d.* per hour on January 3 next, and of 4*d.* per hour on May 1, 1920, when a 44-hour week will come into operation under the terms of an earlier agreement. Smaller increases have been given to the workmen in rural districts. The new scale of wages is to hold good for nine months.

The International Labour Conference created by the Peace Treaty opened in Washington on Wednesday last. Four delegates, two representing the Government, one the employers and one the workers, are attending from each of the States which signed the Covenant of the League of Nations, or acceded thereto, except the United States, Congress having forbidden the appointment of delegates before the ratification of the Treaty; German delegates also will attend later. The subjects to be discussed include the eight-hour day or the 48-hour week, unemployment, the employment of women and children, and permanent organisation.

Judging from the tone of a recent statement to the Press by Mr. J. H. Thomas, the general secretary of the National Union of Railwaymen, the prospects of industrial peace in the railway world appear to be distinctly brighter. The statement, which was made at the termination of a private conference, held on Tuesday last, between representatives of the Government and the executives of the National Union of Railwaymen and the Associated Society of Locomotive Engineers and Firemen, explains that a full and frank discussion took place on the negotiations affecting wages and also on the new Government proposals. It also claims that good progress has been made in the course of negotiations since the strike, towards an agreement between the Government and the railwaymen's executive for a reorganisation of the system under which the railways are managed, with particular reference to the adjustment of railway industrial matters on lines which would give the railwaymen a definite share in the control of the railways. When negotiations were resumed, the railwaymen submitted to the Prime Minister proposals for joint control which they had formulated, many months ago, as a part of their nationalisation programme, but the Government pointed out that these proposals, designed on the assumption that the railways were to be nationalised forthwith, were not applicable to the present transition stage between private ownership and State ownership of the railways. Alternative suggestions were put forward by the Government with the twofold object of satisfying the railwaymen's desire for a higher status in the governance of railways, and of safeguarding the community against sudden and arbitrary stoppages by the provision of effective conciliation machinery. It is understood that the differences between the proposals of the railwaymen and the Government are not too wide to be bridged, and the fact that the Minister of Labour, and Sir David Shackleton left the abovementioned conference before the discussion ended, leaving the negotiations to Sir Eric Geddes, the Minister of Transport, is regarded as a hopeful sign. It is also, perhaps, significant that the conference took place at the offices of the Ministry of Transport and not at No. 10, Downing-street.

Labour Treaty between Italy and France.—The *Sole* reports that the negotiations for the conclusion of a labour treaty between Italy and France have resulted in the signature of an agreement which will be submitted for approval to the Parliaments of the respective countries. The treaty contains 26 clauses, and regulates labour relations between the two countries, arranging so far as possible for equality of treatment as between immigrants and nationals in all that concerns the provision of benefits and assistance.

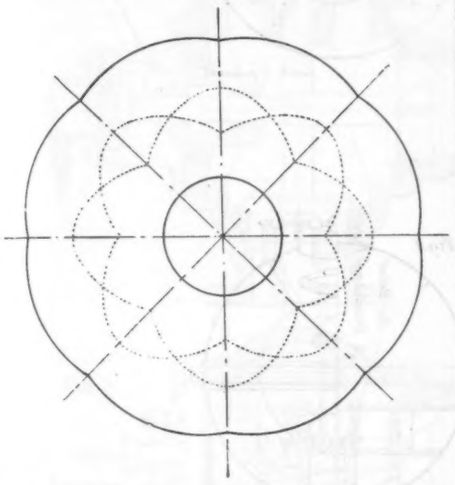
Spare Parts for Motorists.—The finding of a spare part by a motorist is a task calling for the expenditure of much time and patience; therefore the services available to members of the Automobile Association in this connection cannot be too well known. Motorists requiring spare parts are strongly advised, if they are members of the Automobile Association, to communicate with the nearest of the 20 Automobile Association branch offices distributed over the country. During the past few weeks several members have been assisted by the Birmingham Automobile Association office, which has in some cases received requests for spare parts, and sent them to members on the same day. Where the required parts are not available, members are advised on the most economical method for getting them specially made. Members residing in the metropolitan area should communicate their requirements to the Automobile Association and Motor Union, Engineering Department, Fanum House, Whitcomb-street, London, W.C. 2.

GEARED TURBINES AND AIR COMPRESSORS.

TO THE EDITOR OF ENGINEERING.

SIR,—We have noted the reference in your last issue, page 555, to an article on this subject in the *Bulletin de la Société de l'Industrie Mineral*, and think that it might be of interest to state that the installation, consisting of the Laval turbine and the Reavell quadruplex compressor, which is referred to, was one of our double-ended quadruplex machines, fitted with belt pulley.

The article referred to the good results obtained with this machine when compressing to 7 atmospheres in one stage and the explanation of the results obtained, as compared with two-stage compressors of the vertical type, is that, as is well known, in the Reavell machine there are in each casing four cylinders of the single-acting type, and the cylinders are separate castings attached to the casing, with the result that they can be made relatively quite thin, so that the cooling is remarkably good, and as they work in constant thrust the clearance could be,



and is, reduced to extremely fine limits, in the order, in fact, of about one-hundredth of an inch, thus ensuring efficient single-stage compression.

Apart from this, the reason why the plant operated so well is that the turning moment is almost perfectly regular, as is shown by the accompanying diagram. The torque diagrams for each of the four-cylinder compressors making the double unit are shown in dotted lines and, superimposed, is the combined torque diagram which represents the variation of torque at the compressor pulley.

It is only necessary to state that there is no correction in this combined diagram for the weight of the rotating parts, including the pulley, so that it will be realised that the actual torque diagram is almost perfectly regular. These two facts explain the excellent results obtained.

Yours faithfully,

(REAVELL AND CO., LIMITED),
W. REAVELL.

Ranelagh Works, Ipswich, October 27, 1919.

COAL SAVING IN STEEL WORKS AND TIN PLATE WORKS.

TO THE EDITOR OF ENGINEERING.

SIR,—The question of fuel economy is at last being much discussed, and from various points of view, but principally with the object of utilising waste heat. A few remarks of mine may lead to a discussion that may be of service to those considering this subject, and may possibly help some to come to a conclusion after weighing the advantages between the two points of view which I propose to state.

The utilisation of waste heat means very large capital outlay, rearranging of plant and restricting the freedom of lay-out, and the more serious trouble of increased labour and corresponding weakness owing to sectional strikes. The best direction to proceed, as I see it, is that which enables fuel to be saved with reduction of labour and corresponding increased freedom from troubles arising from labour, and with the least increase in capital and reduction in the complications inherent in any scheme for the introduction of waste heat plant. In these notes I propose dealing with steel works and tin-plate works only.

Taking steel works rolling, say, tin-plate bars, about 9 in. by ¼ in. The process is commonly as follows: Coal used for producer gas to run melting furnaces. After running metal into ingots, the latter are placed in soaking pits, also provided with gas to heat them and maintain them at the best temperature for rolling.

Next, coal for boilers to work chargers, cranes for handling ingots to and from soaking pits; cogging and finishing (engines usually exhausting to atmosphere); auxiliary machinery such as shears, bar-cutters, live rollers, pumps, &c. In this letter I only propose to deal with the power side of the proposition.

The coal used in producing steam to drive cogging engines, finishing engines and auxiliaries, including electric light, may be taken as 360 lb. per ton. This figure is the mean of the results at three steel works turning out nearly the same bar from the same sized ingot.

The result of two works turning out similar bars, but driven by electricity, No. 1 taking their electricity supply from a central supply and No. 2 from their own station, are tabulated below. The energy from the works drawing their supply from the Central Supply Company is considerably more economically worked. The results are:—

	No. 1. Energy from Public Supply. Units.	No. 2. Private Plant. Units.	Mean. Units.
Roughing ...	9	12	10·5
Finishing ...	24	33	28·5
Electric light and auxiliaries	7	7	7·0
	40	52	46·0

Converting the energy into coal consumption at 3·5 lb. of coal per unit delivered at the motors, this would result in a consumption of 140 lb. per ton, 182 lb. per ton and 161 lb. of coal per ton, respectively, or a saving in coal consumption in each case of 220 lb., 178 lb. and 199 lb., showing that as much coal can be saved in this manner as would be saved should all the waste heat be satisfactorily utilised. Moreover, this mode of driving simplifies the works in several ways, but principally by doing away with the boilers for steam generation, and consequent extravagant week-end labour costs. There are no restrictions in arranging the lay-out plant, maximum speed is maintained and consequently a better article is produced. There are no losses of speed and output due to variation in boiler pressure, condensing and feed-water troubles are eliminated, and there are reductions in the expense of carting ashes and providing dump land. Rolls cannot stall, as unlimited (practically speaking) power is behind the motors. Power can be cut off if not required and started without loss of time. Allowing for loss of time, stoppages would cause the energy consumption of the private plant to be much higher than that supplied by the central power, as they cannot shut off boiler power at a moment's notice, and there is not the incentive to economy when the supply is their own (which itself introduces further cost for wear and tear), as when energy is purchased. I am not at liberty to give the names of the works above alluded to, and this is a pity, as they are both to be congratulated on the results obtained.

Extensions can also be made with freedom, and instead of investing money in plant and machinery in a business which is outside that of making steel and rolling bars, it can be more profitably employed in the proper business for which the works exist.

Next as to tin-plate works. "These works take the bars supplied by the above-mentioned steel works, and cut them into suitable lengths. They are then passed into a heating furnace; from this heating furnace they pass through the first set of rolls—'roughing rolls'—from which they pass again to a heating furnace, then through finishing rolls, and the plates are doubled. They are again passed into the furnace and reheated, and again through the finishing rolls, and again doubled. This process continues until they get doubled into eights (in other words, the sheet, when it passes through the rolls for the last time is made up of eight laminations). They are then stacked by the mill-man on to his watch pile. From here they go to the finishing shears, and are then opened out (*i.e.*, each lamination is separated). From there they pass to the pickling; this operation is usually carried out by mounting the separate plates into cradles actuated by power, usually steam, and douses these plates into a weak solution of acid. From the pickling, they are then stacked into annealing pots and placed in an annealing furnace (this process is called black annealing). On withdrawing from the annealing furnace, the plates are passed through cold rolls, the principal object being to prepare the surface of the plates for the ultimate tinning. After this process the plates are again annealed (called 'white annealing'). Once more they pass through a second pickling. The plates are then ready for the tin-house, the plates here passing through a bath of tin and flux, and are afterwards cleaned and made ready for the assorting table, and ultimately for packing into the boxes suitable for their size."

The coal consumed in tinplate works, taking the average of three works comprising one very large works, one medium size and one small, and stated in pounds of coal per box of tin plates, is as follows:—

Power. Lb.	Furnaces. Lb.	Annealing. Lb.	Tin and Scruff House. Lb.	Total. Lb.
63·20	32·25	22·60	12·79	130·84

The power includes rolling mills, bar cutters, shears, doublers, cranes, electric light and workshops.

The energy consumed by three electrically-driven mills, two driven by alternating current, one with direct pinion gearing, and one direct-current with rope drive, results in the following mean figures:—

Rolling mills: 8·4 units per box of 20 to the ton, 1·91 units per box of 20 to the ton for auxiliaries; or a total of 10·31 units per box all in.

Allowing 3·5 lb. of coal per unit delivered to motors = 36·085 lb. coal, say 36·1 lb. of coal per box, whilst the lowest consumption per box recorded over a considerable period was 9·8 units at 3·5 lb. = 34·3 lb. of coal per box, as against 63·2 lb., or a difference of 27·1 lb. of coal, and equal to 42·7 per cent. saving in favour of the electric drives. A very great economy of coal can therefore be obtained by electrifying.

Of the three works mentioned, two take their supply of energy from a supply company, and in each case show a lower energy consumption than when the power is supplied from works plant. This economy can be obtained without interfering with the furnaces, &c., which are the outcome of growth of experience, and therefore dangerous to change excepting after due trial and strict examination, and a sure and certain knowledge that such changes will be beneficial.

The reasons given as advantages favourable to electrification in steel works equally apply in the case of tin-plate works also. I have not launched out into elaborate details, leaving that to grow if necessary out of any discussion that may arise, and upon information that may be volunteered as to running by other engineers.

I am, yours truly,

J. E. STEWART, M. Inst. C.E.

September 29, 1919.

BOILER EXPLOSION AT NORTH WOOLWICH.

A REPORT has been issued by the Board of Trade, under the Boiler Explosions Acts, 1882 and 1890, with regard to an explosion which occurred on February 19 last at the Beckton Gas Works, North Woolwich, belonging to the Gas Light and Coke Company.

The boiler, the report states, was of the usual Babcock and Wilcox water-tube land type, having 180 tubes 4 in. in external diameter, and 18 ft. in length. These tubes were expanded at each end into headers which connected the two steam and water drums, 4 ft. in diameter and 23 ft. in length. The boiler was fitted for working under forced draught, and was provided with the usual mountings, the safety valves being loaded to 125 lb. per square inch. It was made in 1912 by Messrs. Babcock and Wilcox, Limited, Oriel House, London. Various repairs were made during the years 1914 to 1918 inclusive, and these are enumerated in the report.

The boiler was insured with the National Boiler and General Insurance Company, Limited, the last thorough inspection being made on August 18, 1918. It had also been frequently examined by the power superintendent and the foreman boiler maker at the works.

In describing the explosion, Mr. Thomas Miller, Assistant Surveyor to the Board of Trade, who had made an examination, states in the report that the seventeenth tube in the second row from the bottom, ruptured longitudinally along the lower side for a length of 9¼ in. at a distance of 7 ft. from the front header. The stop valve was closed immediately, and the contents of the boiler, which was then at a pressure of 125 lb. per square inch, escaped through the opening in the tube in a period of from 3 to 4 minutes. The stoker was slightly injured, but completely recovered, and was able to resume work in two or three weeks after the explosion.

The cause of the accident was overheating of the metal owing to an excessive accumulation of scale and sediment in the tube.

The report goes on to say that the tube which failed in this case was of solid-drawn steel and was one of those originally fitted in the boiler. It showed signs of bulging over a length of 2 ft., and the metal had been consequently thinned until it was reduced to No. 16 S.W.G. in the vicinity of the rupture. When he examined the boiler, Mr. Miller adds, a few days after the explosion, he found the tubes to be very heavily coated with scale, and quantities of loose scale and sediment had collected at places in the lower rows. The boiler had not been thoroughly cleaned since August last, but was next in turn to be cleaned when the explosion occurred.

The boiler was known as No. 62, and was one of a group of eight Babcock and Wilcox boilers used at these works for supplying steam to the oil-gas generating plant. There was a very small margin of boiler power, and during last winter, when, owing to war exigencies, the maximum output had to be maintained, it was necessary to keep seven boilers working continuously at their full capacity. Consequently only one boiler at a time could be off for cleaning purposes, and, as the operation of cleaning occupied a month in each case, the working periods of the boilers were much too lengthy.

The management fully realised this fact, and in December last took steps to increase the boiler plant, ordering other four boilers, which are now, the report states, under construction. These, together with the renewal of the gas generating plant, which is now in hand, will ease the rate at which the boilers are worked, and will enable them to be cleaned more frequently. Meanwhile, matters have been considerably improved by the adoption of a pneumatic tube scaler, by means of which the time taken to clean a boiler has been reduced to ten days.

In some "observations" at the end of the report, Mr. Thomas Carlton, the Engineer Surveyor-in-Chief to the Board of Trade says: "The boiler had of necessity been hard worked for a considerable time and there were but few opportunities for cleaning it; as a result, loose scale and sediment accumulated in the lower tubes, and this led to the overheating and final rupture of one of them." Those responsible fully realised that the intervals between the cleansing of their boilers were too lengthy, and additional boilers are to be installed to remedy matters, by increasing the margin of power available; but from the fact of the tubes being heavily coated with scale," Mr. Carlton adds, "it would appear that the feed water is not as free from solid matter as is desirable for use in boilers of the water tube type."

PERSONAL.—Mr. W. R. Cooper has relinquished his position as editor of *The Electrician*, but will continue his consulting practice as hitherto at 82, Victoria-street, London, S.W. 1.

THE BRUDE COMBINED LIFEBOAT AND LIFE RAFT.

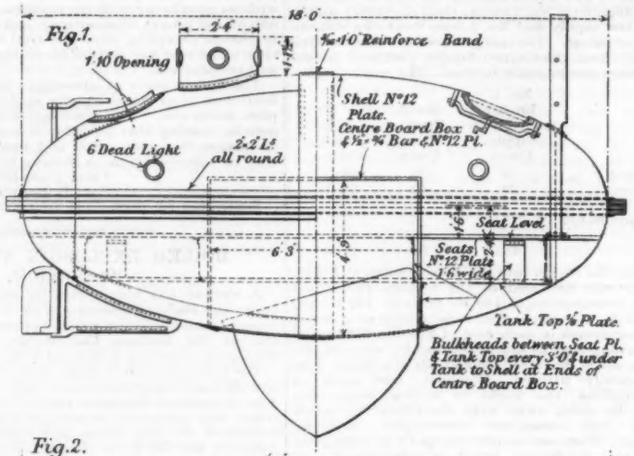
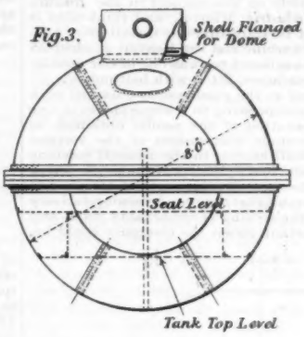


Fig.1.
18·0
2·4
¾×10 Reinforce Band
1×10 Opening
Shell N°12 Plate.
Centre Board Box of 4½×¾ Bar & N°12 Pl.
6 Dead Light
2×2 L's all round
Seat Level
6·3
Seats N°12 Plate 1ft wide
Tank Top ⅜ Plate.
Bulkheads between Seat Pl. & Tank Top every 3·0 & under Tank to Shell at Ends of Centre Board Box.



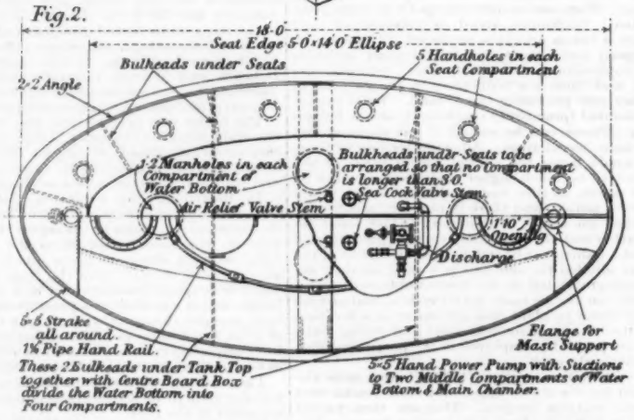
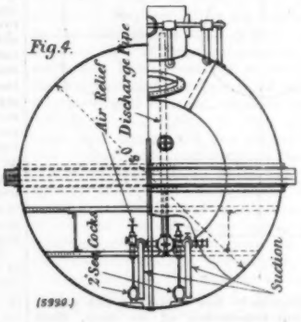


Fig.2.
18·0
Seat Edge 5·0×14·0 Ellipse
Bulkheads under Seats
5 Handholes in each Seat Compartment
2×2 Angle
12 Manholes in each Compartment of Water Bottom
Bulkheads under Seats to be arranged so that no Compartment is longer than 30'.
Sea Cock Valve Stem
Air Relief Valve Stem
1·10 Opening
Discharge
6×5 Strake all around.
1¼ Pipe Hand Rail.
Flange for Mast Support
These 2 Bulkheads under Tank Top together with Centre Board Box divide the Water Bottom into Four Compartments.
5×5 Hand Power Pump with Suctions to Two Middle Compartments of Water Bottom & Main Chamber.



Some time ago attention was drawn by correspondence in our columns to completely enclosed life-boats, principally in the Norwegian Navy, and we reproduce above complete drawings of one of these widely-adopted boats—the Brude combined life-boat and raft. These drawings are reproduced from the *International Marine Engineering*, and are so detailed that there is no need here to enter into a complete description. The boat, it will be seen, has the form of an ellipsoid, built up of steel plates and ballasted with water in four compartments, so that it cannot be capsized. It has a buoyancy of 18 tons and a capacity inside the hull for 44 persons, while 30 more can find space within the railing on the deck. Two manholes, as shown, give access to the interior, and the small conning tower permits observation when the hatches are closed down. Seats for 40 persons are provided, and the lockers have a capacity for a month's food supply for this number. It will be seen that a mast for a sail can be rigged up, while oars can be used. A centre-board may be used also, if necessary, for beating into the wind. This type of boat has been a compulsory equipment of certain ships sailing under the Norwegian flag for the past two years, and is being introduced in American ships by the Brude Lifeboat Company, of New York City.

Proposal to Establish a French Trade Bank.—A Bill has been presented to the French Chamber of Deputies, says *The Board of Trade Journal*, for the purpose of approving the creation of a trade bank, which will provide financial facilities for the export trade. It is pointed out that the long credits essential in commercial transactions with buyers in foreign countries, particularly in Latin America, and also the Far East, and in certain countries of the Levant, have operated against French exporters, who have not had the same facilities in this respect as have British, United States and German shippers, and to this fact is attributed in great part the relatively poor position of the French export trade. The Bill proposes the establishment of a French National Bank of Foreign Commerce, with an initial capital of 100,000,000 francs. The bank will possess an organisation for the development of long-term credit business abroad, and will also collect information likely to be of service in connection therewith and to exporters. It will also establish branches, agencies and connections abroad to work in co-operation with the central organisation at home, and a special reserve fund will be formed for this purpose from money, including an annual subsidy, provided by the State.

BOILER EXPLOSION AT KINGSTON-ON-THAMES.

A report has been published by the Board of Trade on a preliminary inquiry conducted under the Boiler Explosions Acts, 1882 and 1890, with regard to an explosion which occurred on November 21 last at the Central Electricity Works belonging to the Corporation of Kingston-on-Thames.

The report states that the boiler was of the usual Babcock and Wilcox water-tube land type, having 108 tubes. It had the usual mountings, the safety valves being loaded to 150 lb. per square inch. The boiler was made by Messrs. Babcock and Wilcox, Limited, Farringdon-street, London, in 1897, and was therefore about twenty-two years old. The tube which failed was stated to be one of those originally fitted. Various repairs had been made from time to time, particulars of which are given in the report, these dating from 1902 to 1912, there being no record of any further repairs since the latter date. The boiler was insured by the Vulcan Boiler and General Insurance Company, the last thorough inspection being made on April 12, 1918. Mr. T. A. Kingham, the acting borough electrical engineer, also inspected the boilers from time to time when opened up for cleaning.

The second tube on the right-hand side of the fourth row ruptured longitudinally through a length of about 15 in. along the lower side, commencing about 3 ft. from the front header. The contents of the boiler escaped through the opening so formed. The boiler attendant was somewhat scalded, but resumed his duties shortly after.

The failure of the tube seems to have been mainly due to deterioration of the material, the tube being also wasted in the vicinity of the rupture but not dangerously so.

In his "General Remarks," Mr. Longstaffe, engineer surveyor to the Board of Trade, who conducted the inquiry, gives further information :—

"There were four Babcock and Wilcox boilers at the Kingston electricity station for supplying steam to the generating plant, the boiler from which the explosion occurred being known as No. 4. They were fed with water taken from the Thames, treated by a softening plant. It was the practice to clean the boilers every twelve months, the one in question being cleaned in April, 1918, and was last tested by hydraulic pressure on June 13, 1917, when it was subjected to a pressure of 225 lb., the test being witnessed by one of the insurance company's inspectors." Further details are given in the report as to the occurrence of the failure, and Mr. Longstaffe adds full particulars of his examination of the ruptured tube after its removal from the boiler. He found a number of fine surface cracks running longitudinally in the vicinity of the rupture on the outside of the tube, some of which penetrated through half of the thickness; it was also slightly pitted on the inside A strip cut from the tube adjacent to the rupture was subjected to a bend test, and showed the material to have become very brittle. There were also indications of overheating at some period previous to the failure. Considering the tube had been in use for a period of twenty-two years, Mr. Longstaffe says: "I am of the opinion that failure occurred through the material of which it was made becoming so deteriorated that it was no longer able to withstand the stresses to which it was subjected."

In some "observations" of the Engineer Surveyor-in-Chief to the Board of Trade, Mr. Carlton concludes the report as follows :—

"The tube failed in the ordinary course of working, apparently owing to deterioration through long usage, it being one of the original tubes fitted in the boiler some twenty-two years ago. It would probably be very difficult to have detected the defective condition of this tube before it burst, but in view of what has now happened, the condition of the material of the other tubes of the same age should be carefully ascertained, for which purpose it may be necessary to withdraw a proportion of them and subject the material to bending tests."

Water for Washing Cars.—The Automobile Association has been informed of a number of cases in which unauthorised charges have been made for water used for washing cars, and where the association has had an opportunity of taking the matter up with the authorities, the item has been deleted from the water rate notices. Shortly, the position is that in the absence of any special powers giving authority for such charges, the supply of water to private individuals for washing motor cars comes within the supply for domestic purposes, and in these circumstances no extra charge can legally be made.

Office Accommodation at Calcutta and Bombay.—British firms intending to open offices in Calcutta or Bombay are advised by H.M. Trade Commissioner to make arrangements in order to secure adequate office accommodation and residences for their staff. There is at present a serious shortage of housing accommodation for Europeans in these cities. Speculation in land and houses has been active in recent months and great profits have been made. The result is that in order to secure an adequate return on capital rents have been increased in many cases by 50 per cent. and over, and householders are obliged to pay as it is impossible to secure accommodation elsewhere.

THE COXON AUTOMATIC STOP VALVES.

CONSTRUCTED BY MESSRS. J. BLAKEBOROUGH AND SONS, LIMITED, ENGINEERS, BRIGHOUSE.

Fig. 1.

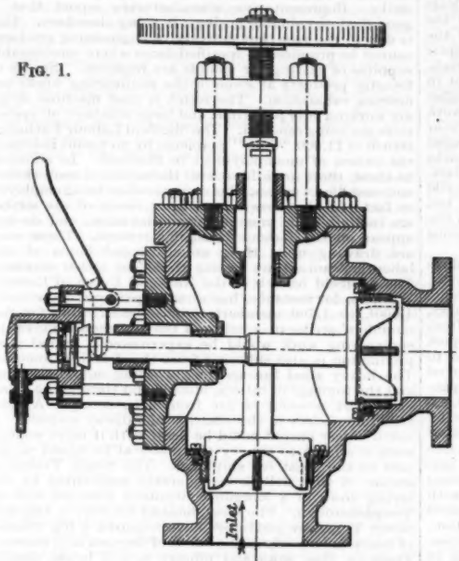


Fig. 2

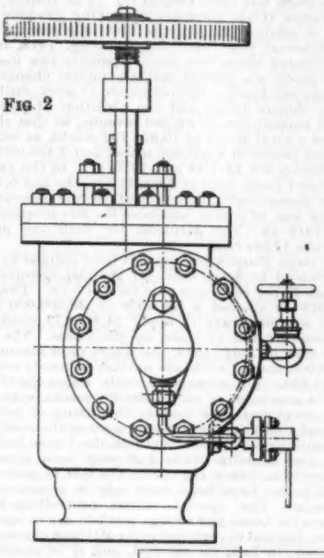


Fig. 8.

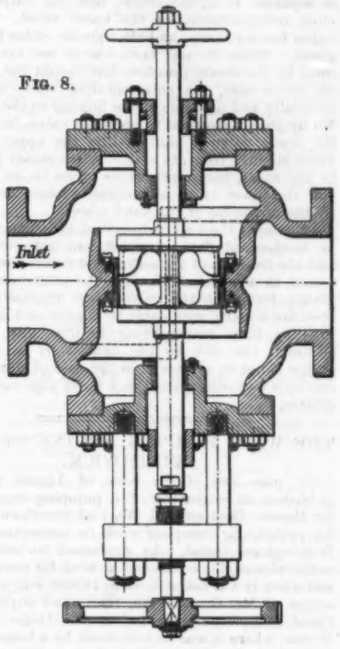


Fig. 3.

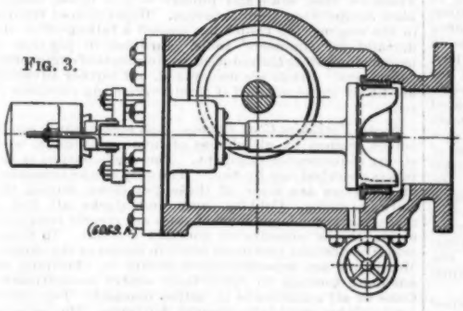


Fig. 4

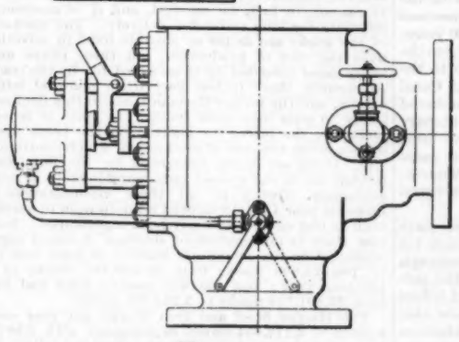


Fig. 9

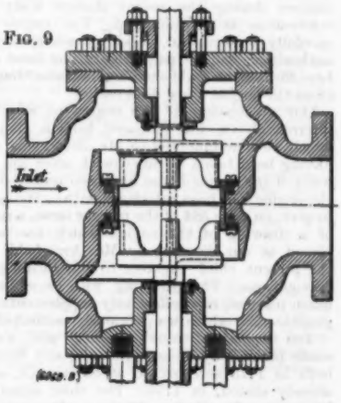


Fig. 7.

Fig. 5.

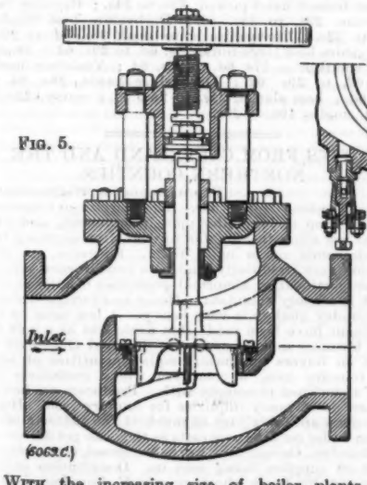
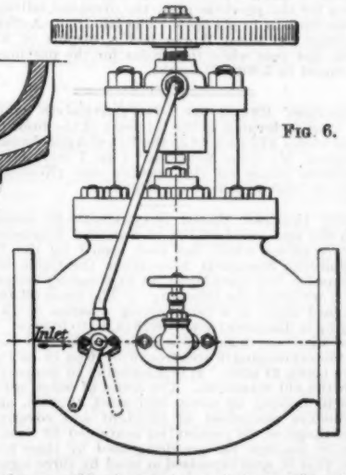


Fig. 6.



With the increasing size of boiler plants, the advisability of having some device which will automatically shut off steam in the event of a burst in the steam main, or a corresponding accident to the apparatus to which steam is supplied, is becoming more and more recognised. It is true that such emergencies rarely happen, but when they do, and most engineers know of one or more cases, the consequences are liable to be dangerous to life and destructive of property. Messrs. J. Blakeborough and Sons, Limited, of Brighouse, Yorkshire, have put on the market a series of valves known as the Coxon valves, designed to afford protection automatically to the workers and the plant in case of accident. The condition under which automatic stop valves have to work are various, but they all depend for their action upon the drop in pressure which occurs in a steam pipe when a sudden large escape of steam takes place. The valve illustrated in Figs. 1 to 4, annexed, is a boiler junction valve, the vertical spindle of which, controlled by the hand wheel, closes the outlet from the boiler in the ordinary way. On opening this valve steam is admitted to the body of the casing. The small by-pass valve outside the casing is then opened, and the steam pressure is thus equalised on both sides of the horizontal automatic valve. This valve, then opens owing to the unbalanced pressure upon it, due to the area of its spindle, and steam flows from the boiler into the main. Should the main burst, the relief of the pressure on the outlet side of the valve causes the automatic valve to close, thus isolating the boiler. It will be noticed, from Fig. 1, that the end of the spindle of the automatic valve carries a piston sliding within a small cylinder. The area of this piston is greater than that of the valve spindle, and thus the admission of steam at the back of the piston at any time will bring about the immediate closing of the valve. This feature enables the automatic valve to be closed positively from any distant point, when desired.

The valve illustrated in Figs. 5 to 7 is designed to take the place of an ordinary stop valve, as it combines the usual functions of the latter with the feature of automatic closing if the pressure on the outlet side is reduced. The valve spindle is separate from the operating screw, and between these two parts is a loose piston working in a small cylinder formed in the bridge-piece. The valve is closed by screwing down in the ordinary way, but when the screw is raised the valve is left behind, and remains closed until the pressure on both sides is equalised by means of the by-pass. Then, the unbalanced pressure due to the area of the spindle causes the valve to open, and it will remain wide open until closed by the hand wheel or until a reduction of the pressure below it causes it to fall on its seat and shut off the steam. As in the case of the preceding type, it may be closed positively and instantly from a distance by admitting steam to the small cylinder already mentioned.

The conditions under which a stop valve, used to isolate portions of a steam header, has to work are different from those of an ordinary stop valve. There will, in the general case, be boilers supplying steam to the header on either side of the valve, through which, therefore, the flow may be in either direction, according as more steam is supplied from one side to the other. The Coxon automatic isolating valve for steam headers

is illustrated in Figs. 8 and 9. The casing contains two similar valves, closing in opposite directions. The lower one is forced to its seat by means of the hand wheel and screw, and acts as an ordinary stop valve when closed in this way. The valve spindle, however, is separate from the screw, and the valve can thus close independently of the hand wheel. The upper valve has no screw, and the spindle slides freely in its gland. When in use, both valves are normally held open by the steam pressure, but should the main burst on either side, the corresponding valve closes automatically and prevents steam flowing to the burst part. No by-pass is required to open the valve, because when the lower valve is shut it lifts the upper automatic valve slightly from its seat. When steam is admitted to the main, the upper valve opens to its full extent and the lower valve also opens as soon as permitted by the operation of the hand wheel.

In none of the valves described are there any springs or mechanical devices which can get out of order, and the freedom of the automatic valves can be readily tested at any time. Besides the protection of steam plants, for which the valves were originally designed, they are equally applicable to compressed air mains or to pipe lines transmitting natural gas, in which, although the risk to life caused by an unchecked escape is not so serious as in the case of steam, the loss due to waste consequent on a burst pipe may be much greater.

THE WATT PUMPING ENGINE OF 1776 AT SMETHWICK.

On page 286 of our issue of August 29 last we published an engraving of a pumping engine erected by Messrs. Boulton and Watt at Smethwick in 1776, for performing pumping work in connection with the Birmingham Canal. As explained in our previous notice this engine continued at work for over 100 years, and when it was taken down in 1898 it was, owing to the action of Mr. G. R. Jebb, then chief engineer to the Canal Company, re-erected at the Ocker Hill Canal Works, where it was seen at work by a large number of visitors during the recent James Watt Centenary celebration at Birmingham. The engine has been carefully preserved in working condition by the canal authorities, and on page 415 of our issue of September 26 last we published an indicator diagram taken from the engine a few days earlier.

Our illustration of the engine to which we have referred above, was prepared from a photograph for which we were indebted to Mr. Jebb, this photograph having been taken at Smethwick after one of the side walls of the engine-house had been removed but before the engine had been interfered with. We are now able to give, on page 584 of the present issue, a reproduction of a drawing of the engine which has been kindly placed at our disposal by Mr. Archibald W. Willet, the present chief engineer to the Birmingham Canal Navigations. This drawing will be examined with much interest, as it effectively supplements the photographic view which we previously published.

The engine illustrated, we may add, was the first made for sale by Messrs. Boulton and Watt. It was built in 1775 and erected at Smethwick, as we have already stated, in 1776. The chief dimensions are: Diameter of cylinder, 32 in.; diameter of pump, 29 in.; stroke, 8 ft. It was run with steam at 10 lb. pressure at the speed of 13 strokes per minute. The indicator diagram to which we referred above was taken when the speed was 14 strokes per minute.

It is much to be hoped that one result of the recent Centenary celebrations will be to secure for this engine a suitable permanent home where it may be preserved in thorough working order and be readily accessible for inspection. Meanwhile all engineers should feel deeply grateful to the Birmingham Canal authorities for their action in so effectively maintaining such an exceedingly interesting relic.

Establishment of British Companies at Trieste.—The Department of Overseas Trade is in receipt of a despatch from His Majesty's Consul-General at Trieste giving information as to the formalities with which British companies must comply at the present time in order to establish themselves at Trieste. According to the report received it would appear that while Italian legislation has not yet been generally established in the Province of Venetia Giulia and its chief town, Trieste, in certain cases the Italian Government has expressly decreed the immediate application of the Italian law, and it is now applied to foreign companies established in that province. British and other foreign subjects enjoy equal rights with citizens of the country, and are enabled to act as merchants, charterers, ship-chandlers and forwarding agents. Firms may be required to enrol in the Register of Commerce kept by the Commercial Court, and are then considered as merchants subject to the Court of Commerce. Joint stock companies must comply with the provisions laid down in the Italian Commercial Code. A copy of the report received may be consulted by firms interested at the inquiry office of the Department of Overseas Trade, 73, Basinghall-street, London, E.C. 2.

THE PRESENT POSITION OF GERMAN INDUSTRIES.

As reports and balance sheets from the German heavy industries appear they show clearly the difficulties under which work has been carried on. The United Königs und Laura Hütte furnishes a striking example of the state of affairs. During the first four months of the last financial year, viz., July-October, 1918, in spite of increasing wages and more expensive raw materials, a fair profit was gained, but a complete change set in with the revolution. Disinclination to work, still higher wages, shorter hours and the abolition of piece-work caused expenditure to exceed revenue, so that the year showed a total deficit of 10,824,492 marks, as compared with net profits of 8,500,000 marks and 9,800,000 marks respectively for 1917-18 and 1916-17. In the two last-mentioned years sums of 3,600,000 marks and 5,100,000 marks respectively, were added to the reserves, but nothing was, of course, available for this purpose in the year 1918-19. The dividend for both the previous years was 12 per cent.

The large Phœnix concern has been obliged to reduce its dividend to 8 per cent. for the last financial year, whereas 20 per cent. was paid for 1917-18. The profits for 1918-19 showed a decrease of 36,600,000 marks, and it was necessary to apply 24,804,473 marks from the reserve funds to make up the losses. The report states that in July, 1919, the wages paid amounted to 18,000,000 marks, while the number of hands employed was 37,820. The average monthly wages for the year 1913-14 amounted to only 5,800,000 marks, with 40,000 hands employed. As regards the fixing of prices by the Steel Union it was stated that since the abolition of maximum prices for steel and iron the Union had a free hand, but actually prices had only been raised just sufficiently to follow the rise in the cost of production; of late prices have been fixed only in agreement with consumers. The special unions controlling finished products for home and foreign markets are in operation, and the demand is very strong for all these commodities. It cannot, in fact, be satisfied, and it is necessary to stipulate for long terms for delivery. The quotations of the works are as far as possible fixed in accordance with the cost of production, but these prices are in many cases exceeded by those asked for by the traders. Apparently there is but very little material left for export, and the former German trade in this field seems likely to pass into other hands. In spite of repeated increases, the prices for pig-iron on the home market do not cover the cost of production, which continues to rise. Costs are being influenced by the purchase of foreign ore in the present unfavourable state of foreign exchanges. Owing to all these circumstances the financial year 1918-19 showed a diminution in earnings, such as had never previously been experienced. In this case there is no question of shortage of liquid capital, inasmuch as the company's balance in hand had risen to 106,625,090 marks from 46,459,381 marks in the previous year; but the war reserve fund had fallen from 23,891,719 marks to 3,232,313 marks.

The Hasper Steel and Iron Works last year earned a profit of 2,119,654 marks, as compared with 4,889,161 marks for the previous year, the dividend falling from 16 per cent. to 10 per cent. The Hindrichs-Auffermann Munition and Metal Works had a surplus of 325,416 marks last year while the profits for the previous year amounted to 2,509,067 marks.

Brewers' Exhibition.—The thirty-sixth exhibition and market devoted to the interests of the brewing and allied trades will be held at the Royal Agricultural Hall, Islington, N., from November 1 to 7 inclusive. The exhibition closes on the opening day (November 1) at 6 p.m., and on other days at 8 p.m.

New Electric Cable Standards.—In connection with the new standard list of sizes and dimensions for electric cables which has been issued by the British Engineering Standards Association, the Cable Makers' Association has distributed an explanatory letter from which we quote the following: "The basis (of the new standard sizes) is a table giving a series of 13 wires ranging in diameter from 0·0076 in. to 0·1030 in. From these wires are drawn up a table of solid and stranded conductors ranging in area from 0·0010 sq. in. to 1 sq. in., there being 24 sizes. It is interesting to compare these with the old standards. The series of wires ordinarily used in making up cables embodied 25 sizes, and the conductors recognised as standard and covering the same range as the present list contained 59 sizes. The sizes in the new list are designated by their nominal area, that is, area expressed at most by three significant figures, these nominal sizes being within a very small percentage of the actual calculated area. Corresponding to the standard ordinary conductors are two tables of flexible conductors. . . . It has been argued by users that it would be convenient if details and prices were published per thousand yards, and that the standard coil for both cables and flexible cords should be 100 yards, and this course has been adopted, both in the standards specification and in the manufacturers' catalogues, except as to the designation of insulation resistance which, to avoid confusion, is given on a mile as heretofore. The greatest difficulty in a change of this kind will be to overcome habits of specifying or asking for old sizes. During the war customers were only too glad to take what they could get on the market, and this fact has shown most of them that there is no real gain in the use of other than standard sizes. The change has been made at the express wish of users of cable, and it is hoped that the industry will unite in adopting and as rapidly as possible using, only the new standard sizes."

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—There are more inquiries on export account for steel, tools and machinery than since the end of the war, but contracts are held up by the moulders' strike. Representative manufacturers report that a good deal of valuable business is going elsewhere. This is due to the fact that delivery of engineering products cannot be promised to specified dates where considerable supplies of castings or moulds are required. Stocks of foundry products at some of the engineering works are nearing exhaustion. The result is that machine shops are working only part time, and large numbers of operatives are being released. The Sheffield Labour Exchange return of 11,000 "dole" recipients by no means indicates the extent of unemployment in Sheffield. In addition to these, there are idle several thousands of semi-skilled and unskilled workers, who, owing to their being employed in factories shut down as a direct result of the strike, are ineligible for unemployment donation, and do not appear on the Labour Exchange returns. These men are drawing upon their union funds. Some of the labourers' unions are feeling the effect rather severely. The Sheffield branch of the National Union of General Workers, for instance, has already paid out close upon 4,000*l.* to 1,700 members thus affected. But for the moulders' strike it is believed that a general revival in engineering work would be experienced. Actual steel production is also suffering from the dearth of moulds. The heavy steel furnaces are working only half-time, and the tonnage of billets, blooms and slabs going away on export account is far from satisfactory. A contributory defect is the scarcity of railway wagons. A much bigger output could be dealt with if more wagons were available to convey the material to inland works and to the coast for shipment. The South Yorkshire output of wire will be considerably augmented by the laying down of a Morgan continuous wire rod mill at Templeborough. The local demand for wire is healthy. South Yorkshire producers have acquired a big volume of business formerly in the hands of German mill masters. Trade in files, saws and pincers is still brisk, despite keen competition from America. Repetition of trouble in the engineering trades has caused a falling-off in the demand for engineers' tools. Business in pig-iron is moderate, despite the reduced requirements of engineering consumers. Prices are unchanged, but further advances are likely to be notified if productive costs continue to rise.

South Yorkshire Coal Trade.—Best steam hards are in active request by all classes of home consumers, with strong inquiries for shipment. The whole output of the pits is absorbed day by day. The only stocks remaining at collieries are some of those put down during the railway strike. Cobbles, nuts and slacks all find a ready market. Open market sales are greatly restricted owing to the pressure on contract account. In house coal, the demand continues much in excess of the supply. Merchants are experiencing difficulty in obtaining an adequate tonnage to cover their winter commitments. Coke of all qualities is in active demand. Top prices are easily procurable for prompt deliveries. Quotations:—Best branch hand-picked, 33*s.* to 34*s.*; Barnsley best silkstone, 33*s.* to 33*s.* 6*d.*; Derbyshire best brights, 31*s.* to 32*s.*; Derbyshire house coal, 28*s.* 6*d.* to 29*s.*; Derbyshire best large nuts, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire small nuts, 27*s.* 6*d.* to 28*s.* 6*d.*; Yorkshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; best slacks, 24*s.* to 25*s.* 6*d.*; nutty, 23*s.* to 24*s.*; smalls, 19*s.* to 20*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—The scarcity of Cleveland foundry iron is becoming more pronounced, and producers are altogether unable to deal with anything like the demands made upon them. Furnaces are still working very irregularly, and as a consequence turning out proportionately abnormal quantities of inferior iron which is already abundant. Home and foreign demand for foundry quality is very heavy. A few sales to the Continent have been made this week, but as a rule for such business makers are more disposed than ever to insist on buyers purchasing equal quantities of forge and foundry iron, a condition which customers are most disinclined to comply with. Producers are having to turn down many inquiries for foundry iron. Home consumers are taking up as much of the better quality of iron under running contracts as they can get delivered, ironfounders, though their works are closed, continuing to insist on supplies being sent in. Distribution is still hampered by truck shortage which, however, is less acute than it has been. For home consumption, No. 1 Cleveland pig-iron is 164*s.*, No. 3 g.m.b. and No. 4 foundry stand at 160*s.*, and No. 4 forge is quoted 157*s.* to 160*s.*, according to brand. Export prices are 5*s.* above the foregoing quotations.

Hematite Iron.—Much better accounts are given of the hematite branch of the staple industry. Ample quotations of iron are available for home purposes and for foreign trade. Very substantial sales to the Continent are understood to have been made recently, and further expansion of trade with customers abroad is looked for notwithstanding obstacles to foreign business. Nos. 1, 2, and 3 East Coast brands are 200*s.* for home use and No. 1 is 202*s.* 6*d.*; whilst export quotations are 205*s.* and 207*s.* 6*d.* respectively.

Foreign Ore.—Signs are still absent of any revival of activity in foreign ore. Consumers have good stocks, and considerable contracts made against which good

supplies are regularly coming to hand, and sellers are a good deal in arrears in deliveries, so that neither are very keen to do new business. Best rubio is 52*s.* 6*d.*; and the freight Bilbao-Middlesbrough is round about 24*s.* 6*d.*

Cleveland Miners' Wages.—The Cleveland ironstone mine owners met the miners' representatives this week, when an agreement was entered into to make no change in miners wages during the present quarter.

Coke.—Demand for coke continues heavy and supply is not over plentiful. Some complaints, in fact, are heard of difficulty, experienced in obtaining sufficient coke to meet requirements at local works. Average blast-furnace kind readily realises the full figure of 48*s.* at the ovens, and low phosphorus sort commands the maximum of 49*s.* 6*d.* at the ovens.

Manufactured Iron and Steel.—There is large demand for finished iron and steel from all quarters, and for nearly all descriptions. Shipbuilding requisites, and railway material in particular, are much sought after. Values are well maintained, and works are running at very high pressure. Common iron bars are 22*l.*; best bars, 25*l.*; steel ship, bridge and tank plates, 18*l.* 5*s.*; steel boiler plates, 21*l.* 10*s.*; steel angles, 17*l.* 15*s.*; steel joists, 17*l.* 10*s.*; heavy steel rails, 16*l.* 10*s.*; black sheets, 25*l.*; and galvanised sheets, 35*l.*—all for home consumption, export rates being slightly above these quotations.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—No change falls to be recorded in the position of the Scotch steel trade, and the strike of the bricklayers, now in its fifth week, still continues. Efforts have been made again to bring both sides together, but the masters decline to reopen negotiations until the men return to work and are willing to work overtime as usual. The result is that a deadlock has been reached and the output of ship and boiler plates has been reduced to a minimum. Consumers of steel material are now beginning to feel the pinch, and there has been a further increase in the number of men affected. A very heavy demand exists for almost all classes of material, but very little is available and the outlook has become serious. Shipbuilders are in great want of ship plates and the general engineering trade is also suffering from want of supplies. The black sheet makers are very busy with many orders on hand, chiefly for the heavier gauges. The rise in prices failed to check the demand and would almost seem to have stimulated it, and there are also good inquiries in the market for lots for shipment. Sectional material is not in much request at the moment. The general export trade is practically at a standstill as there is extremely little to offer owing to the present trouble at the steel works. Prices are without change.

Malleable Iron Trade.—In the West of Scotland malleable iron trade a healthy tone prevails, and all the works are actively employed. The demand for deliveries is constant and makers are doing their best to keep all customers supplied. The orders now booked amount to a considerable tonnage, and most of them are on home account, the export trade not representing any great quantity. Quotations remain unaltered.

Scotch Pig-Iron Trade.—In the Scotch pig-iron trade there has been little change over the week, and a fairly good demand exists. No. 1 iron, which was rather scarce is perhaps just a trifle more plentiful, and there is a good supply of hematite available so that operations, when restarted at the steel works, should not be hampered on the score of scarcity. Shipping inquiries again show signs of improvement, and a number are on the market this week. The output over all is not yet all that could be desired, but hopes are entertained that the tendency towards improvement will continue. Prices are firm.

Scotch Coal Trade.—Fairly satisfactory conditions prevail in the Scotch coal trade this week, at least they are no worse, and, in fact, seem more settled. The output has not yet reached a very high level, and the supply of wagons is at times so limited that it is responsible for some of the shortage in output. The general industrial demand is good and reserve supplies are being made up. There is also quite a large business going through in household sorts. The export trade is limited, but quite a respectable amount of coal is being shipped to Irish ports.

NOTES FROM THE SOUTH-WEST

CARDIFF, Wednesday.

The Local Coal Market.—A shortage of tonnage and wagons continues to inconvenience collieries, and for quick loading prices remain easy, with supplies of practically all grades plentiful. Actual business is quiet and principally confined to purchases for quick delivery. Forward transactions are held in abeyance, as sellers are not disposed to accept current quotations in anticipation of an early influx of tonnage, as it is reported that a fair quantity of shipping has been diverted from the Mediterranean to this district in view of the threatened American strike. A little business has been transacted for delivery over next year on the basis of from 70*s.* to 75*s.* for good quality large coals, and from 50*s.* to 55*s.* f.o.b. for second grade steam smalls. The bulk of this business has been arranged with French railways, and it is understood that negotiations are under consideration for supplies to bunker depots abroad. For quick loading, large coals are obtainable at from 70*s.* to 72*s.* 6*d.*, with best smalls round 55*s.*, good ordinaries 50*s.*, cargo sorts 45*s.* and inferiors from 35*s.* up. Coke is scarce and firm at from 107*s.* 6*d.* to 110*s.*, and though there is a good demand for patent fuel, prices are irregular at from 75*s.* to 80*s.*

Iron and Steel Trades.—The strike of skilled tradesmen employed at the Ebbw Vale, Dowlais and Tredegar steel works has ended, and arrangements made for an early resumption of work. The strike has been in progress for over 15 weeks and involved the idleness of some 15,000 workers, of whom about 1,500 were skilled men. Previous to the strike the rate of pay was 3*l.* 8*s.* 7*d.* per week, plus 5*s.* war bonus. The men demanded a flat rate of 5*l.* per week, which the employers refused. Subsequently the Ebbw Vale Company were stated to have offered 4*l.* 10*s.* per week, plus cheap coal. Later the associated employers made an offer of 4*l.* 5*s.* and cheap coal, or 4*l.* 10*s.* without cheap coal. This offer was rejected, and on Monday a conference representative of employers and men was held at Cardiff and the employers offered the men 4*l.* 10*s.* per week of 47 hours, plus cheap coal where customary, *i.e.*, 41*s.* basis, plus 28*s.* 6*d.* war wage, plus 12½ per cent. war bonus, plus 11*s.* 9*d.* This offer was accepted by the men's representatives, and on Tuesday the settlement was ratified at mass meetings of the men. The associated employers, however, have asked Mr. F. Mills general manager of the Ebbw Vale Steel, Iron and Coal Company, Limited, to resign the chairmanship of the Employers' Association. Mr. Mills has since intimated that he has no intention of tendering his resignation.

NEW SHIPWAYS FOR BALTIMORE.—According to *International Marine Engineering*, it was stated at a special meeting of the Board of Estimates of the City of Baltimore, that the Union Shipbuilding Company plans to spend 8,000,000 dols. for extensions on the Brooklyn side of the Patapsco River. The extensions include the building of six additional concrete ways and the construction of four railroad tracks for the delivery of materials.

UNITED STATES BUREAU OF MINES REPORT.—The eighth annual report of the United States Bureau of Mines deals with the year up to June 30, 1918, and with various industrial war problems. We take a few notes from it. For the oxidation of ammonia pure platinum gauze, 80-mesh screen, is recommended as used over here; it is, however, claimed that the electric heating of the catalyst has successfully been superseded. Although the production of manganese, chromite, pyrite and magnesite had enormously increased, very large bulks of these ores were still being imported; the electric smelting of ferro-manganese and silico-manganese had been found superior to blast-furnace smelting, but it was doubtful whether these processes could survive in normal times. The outputs of potash from the dust of kilns and blast furnaces had also increased; but again the economy of the processes was doubtful. As regards zinc a cheap process of recovering zinc from leached low-grade ores has been evolved; limestone is first added to the leach which contains calcium sulphate; then sulphur dioxide is passed into the vats to form zinc sulphite, which falls out on expelling the excess of the dioxide. The volatilisation of zinc from sulphidic ores has not yet answered. The researches on uranium and radium have been noticed in our columns. Mercury and lead, nickel plating, coking systems, ore flotation, oil storage and breathing apparatus are further noticed in the report.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—The report of council of this Institution for 1918–19 states that no less than 58 different individuals and companies had contributed to the discussions on the various papers. Of these, 34 made their contributions at the meetings in person and the remaining 19 sent their contribution by letter. The total number of contributions received was 63. The average number of contributions on each paper works out at five. Preparations for the establishment of a local association for research in marine engineering were continuing. The engineering and shipbuilding companies of the district had been approached on the subject through their associations. The latter had appointed representatives to meet those appointed by the Institution, and important developments were expected in the near future. The need of systematic, deliberate and co-ordinated research in all branches of industry was now recognised, and there remained the taking of proper measures for the conduct of such research. The normal activities of the Research Committee of the Institution had continued throughout the session. The investigators appointed by the council had carried out a series of tests of an exhaustive character on an apparatus submitted by Messrs. Richardson, Westgarth and Co., Limited, and a report was being drafted for consideration. The report on the education of apprentices published by the Institution in 1917, had met with nothing but the most wholehearted approval by all interested bodies, both educational and industrial. The policy of the council was to take steps with a view to providing adequate machinery for the administration of the Institution's scheme. It was proposed to appoint representatives from among the apprentice masters to sit on the Education Committee. One representative would be invited from each of the three districts, into which the North-East Coast was divided, viz., Blyth and the Tyne, the Wear, and the Tees and Hartlepools. It was hoped that by the establishment of these links between the apprentices and the Institution a real and general improvement in the ultimate technical efficiency of engineering and shipbuilding operatives would be attained with consequent beneficial results to the industries affected and the nation itself. The total membership on July 31, 1919, was 1,351.

NOTICES OF MEETINGS.

THE INSTITUTION OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH.—Saturday, November 1, at 4 p.m., in the College of Technology, Manchester. Mr. W. H. Cook, of Heaton Chapel, will give a paper on "Annealing of Castings," illustrated by lantern slides.

THE SOCIETY OF ENGINEERS (INCORPORATED).—Monday, November 3, at 5.30 p.m., in the Rooms of the Geological Society, Burlington House (in Piccadilly). The proceedings will open at 5 p.m. with a social gathering of members and visitors, after which a paper will be read at 5.30 p.m. on "Sewer Ventilation and Health," by Mr. William Brown.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, November 4, at 5.30 p.m., Opening Meeting. Address by Sir John Purser Griffith, the President, and presentation of medals awarded by the Council.

THE INDUSTRIAL LEAGUE AND COUNCIL.—Tuesday, November 4, the third Lecture of the present series arranged by the Industrial League and Council (incorporating the Industrial Council and the Industrial League) will be held in the Council Chamber of the Guildhall. The chair will be taken at 4.30 p.m. by the Right Hon. J. H. Whitley, M.P., and a lecture on "Higher Commercial Education and the Universities" will be delivered by Dr. Russell Wells, M.D., B.Sc. No tickets are necessary.

THE INDUSTRIAL LEAGUE AND COUNCIL.—Wednesday, November 5, the second of the present series of Conferences on Scientific Management, arranged by the Industrial League and Council (incorporating the Industrial Reconstruction Council and the Industrial League) will be held at 5.30 p.m., in the Hall of the Institute of Journalists, 2 and 4, Tudor-street, E.C. 4. Mr. W. J. Grosert will give an address on "Standard Factory Organisation," and this will be followed by questions and discussion. No tickets are necessary.

THE INSTITUTION OF SANITARY ENGINEERS.—Wednesday, November 5, a sessional meeting will be held in Caxton Hall, Westminster, for a discussion on "The Sanitary Engineer and His Work in Connection with Housing and Town Planning."

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, November 5, at 8 p.m., at the Royal Institution, Colquitt-street, when the president, Mr. J. Hamilton Gibson, O.B.E., M.I.N.A., will deliver his Inaugural Address.

THE ROYAL SOCIETY.—Thursday, November 6, at 4.30 p.m., a Joint Meeting of the Royal Society and the Royal Astronomical Society will be held. Joint discussion on the "Results of the Observations obtained at the Total Solar Eclipse on May 29, 1919," to be opened by Sir Frank Dyson, Astronomer Royal. Professor Eddington and other members of the Eclipse Expedition will take part.

THE TECHNICAL INSPECTION ASSOCIATION.—Friday, November 7, at 7.30 p.m., at the Rooms of the Royal Society of Arts, John-street, Adelphi, a paper will be read by Professor Baly, C.B.E., F.R.S., &c., on "The Spectroscope in the Science of To-day."

THE INSTITUTION OF ELECTRICAL ENGINEERS.—The opening meeting of the session 1919–20 will take place, by kind permission, at the Institution of Civil Engineers, Great George-street, Westminster, S.W., on Thursday, November 13, at 6 p.m., when the president, Mr. Roger T. Smith, will deliver his inaugural address.

DETERIORATION OF COAL BY STORAGE.—In Bulletin 136 of the United States Bureau of Mines, H. C. Porter and E. K. Ovitz gave an account of five years of tests, conducted on behalf of the Bureau and the United States Navy Department, with various coals, chiefly New River coal from Western Virginia. Outdoor weathering did not produce any noteworthy loss of weight, except in the case of a black lignite from Wyoming, which lost 1·2 per cent. of weight in one year, and 2·1 per cent. in two years. Storage under water, fresh or salt, was found to prevent deterioration, but was not recommended as too expensive, except to check spontaneous combustion. This report was criticised by G. Cecil Jones in the *Journal of the Society of Chemical Industry* (February 27 last), who suggested that Porter had overlooked a loss of coal substance by volatilisation as indicated by a steady rise in the ash percentages. Replying to this criticism in the Journal mentioned, of September 30, Porter points out that conclusions based upon averaged ash percentages are unreliable because the ash percentages are irregular. It is not quite clear how far that admission would affect the general results. But Porter objects that the weight fluctuations were practically the same with storage of the coal under water and in air, and that their results had been calculated for ash-free dry coal substance. It is fairly well agreed that coal in general increases in weight by absorbing oxygen, that oxygen may oxidise some carbon and hydrogen and the CO_2 and H_2O formed may remain in the coal or evaporate; the increase in moisture is mostly very small, and the loss of combustible gases had not, in the determinations of the calorific value, amounted to more than 0·16 per cent. in the case of the New River coal. Hence it is assumed that most of the oxygen is merely adsorbed without causing oxidation to an important extent. But it is obviously very difficult to balance the possible losses and increases of weight, especially with variable ash contents in the samples.

THE WATT PUMPING ENGINE ERECTED AT SMETHWICK IN 1776

(For Description, see Page 582.)

Fig. 1.

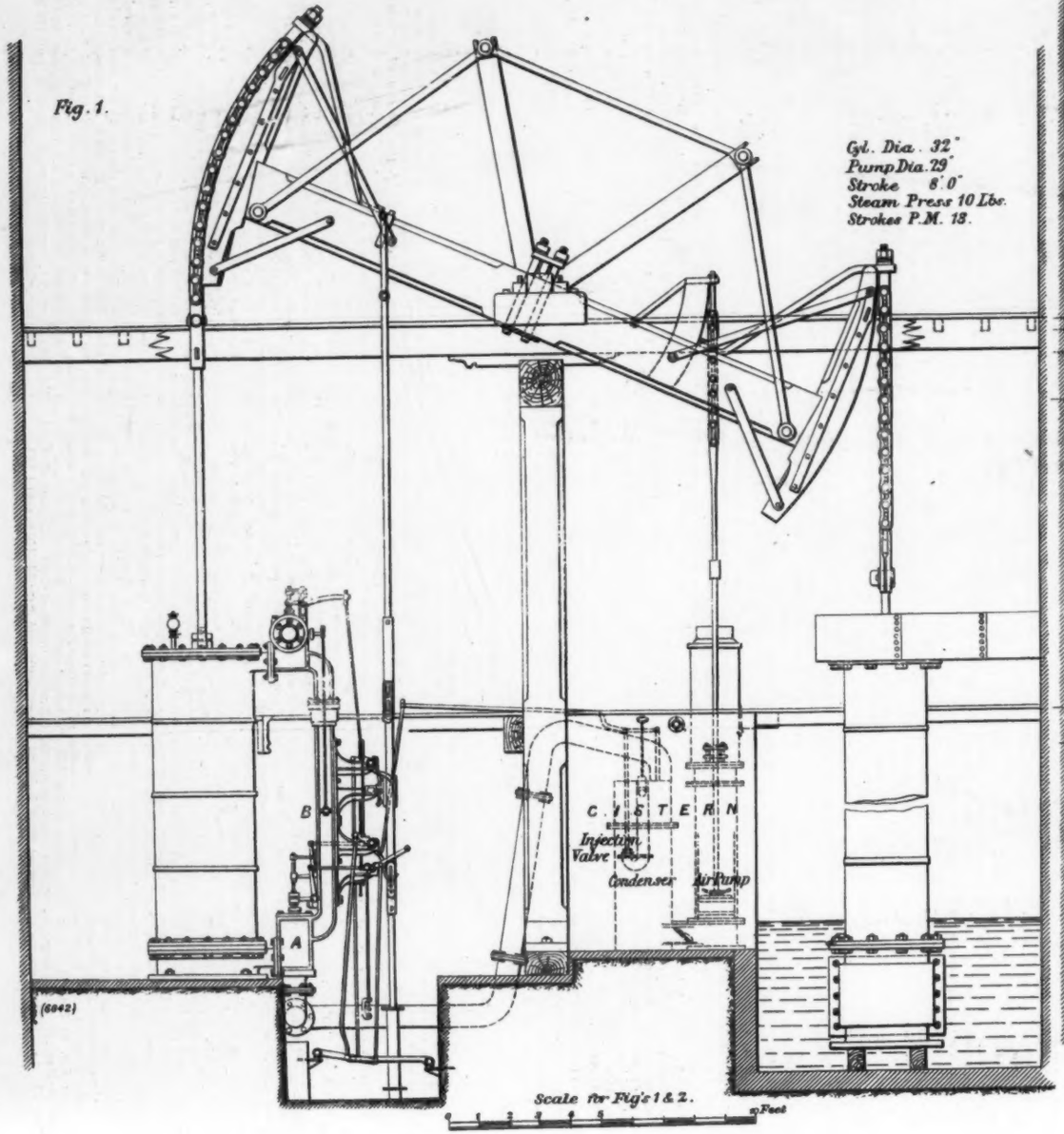
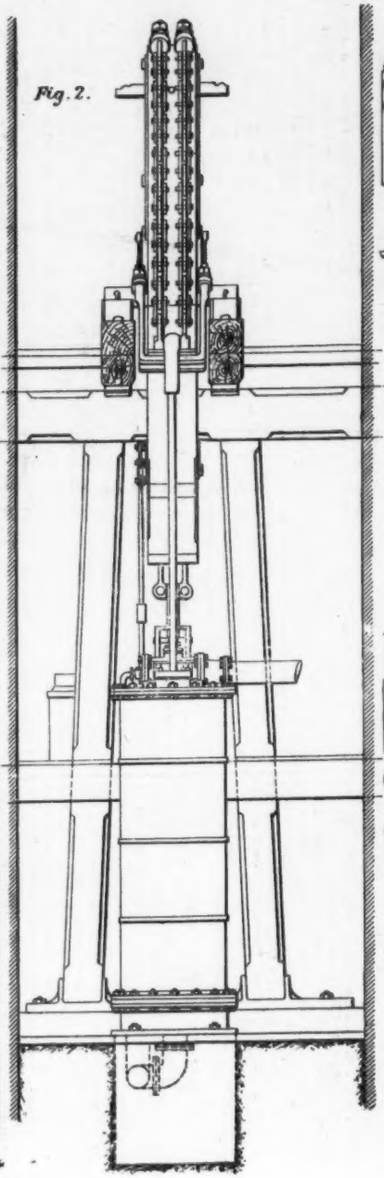


Fig. 2.



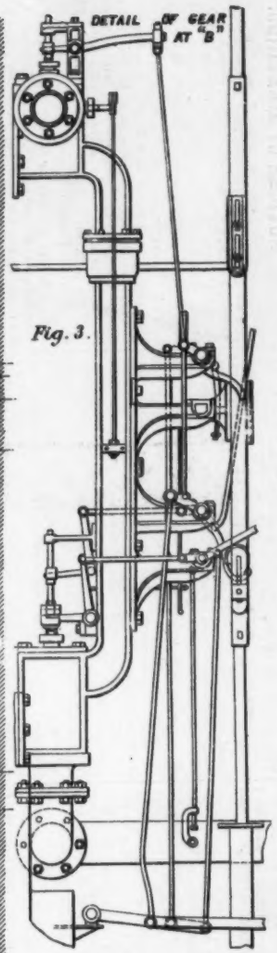


Fig. 3.

VERTICAL SECTION OF VALVE & BOX "A"

Fig. 4.

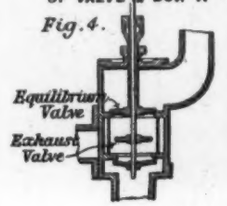


Fig. 2. View showing Cylinders, Valve Gear, and Exhaust Valve under Engine.

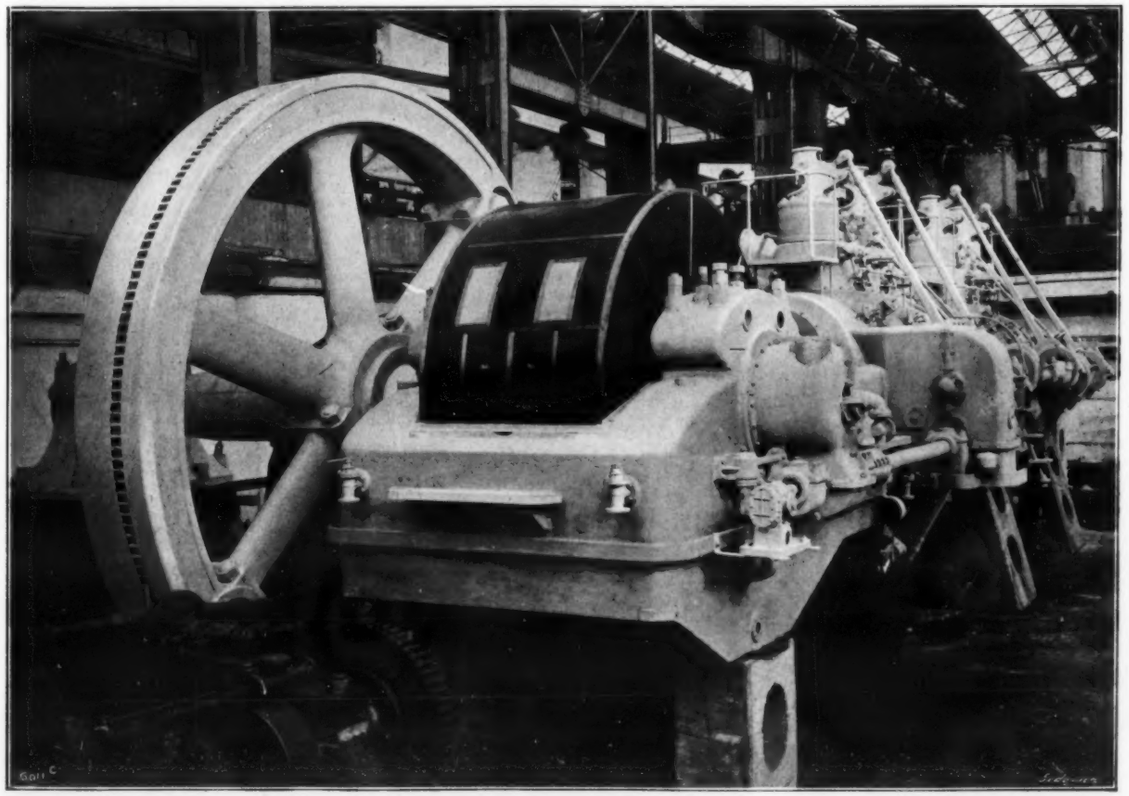


Fig. 3. View from Forward End.

Fig. 4. Connecting-Rod

GAS ENGINES FOR FRODINGHAM AND APPLEBY WORKS OF THE APPLEBY IRON CO., LTD.

CONSTRUCTED BY MESSRS. VICKERS LIMITED, ENGINEERS, BARROW-IN-FURNESS.

(*For Description, see Page 576.*)

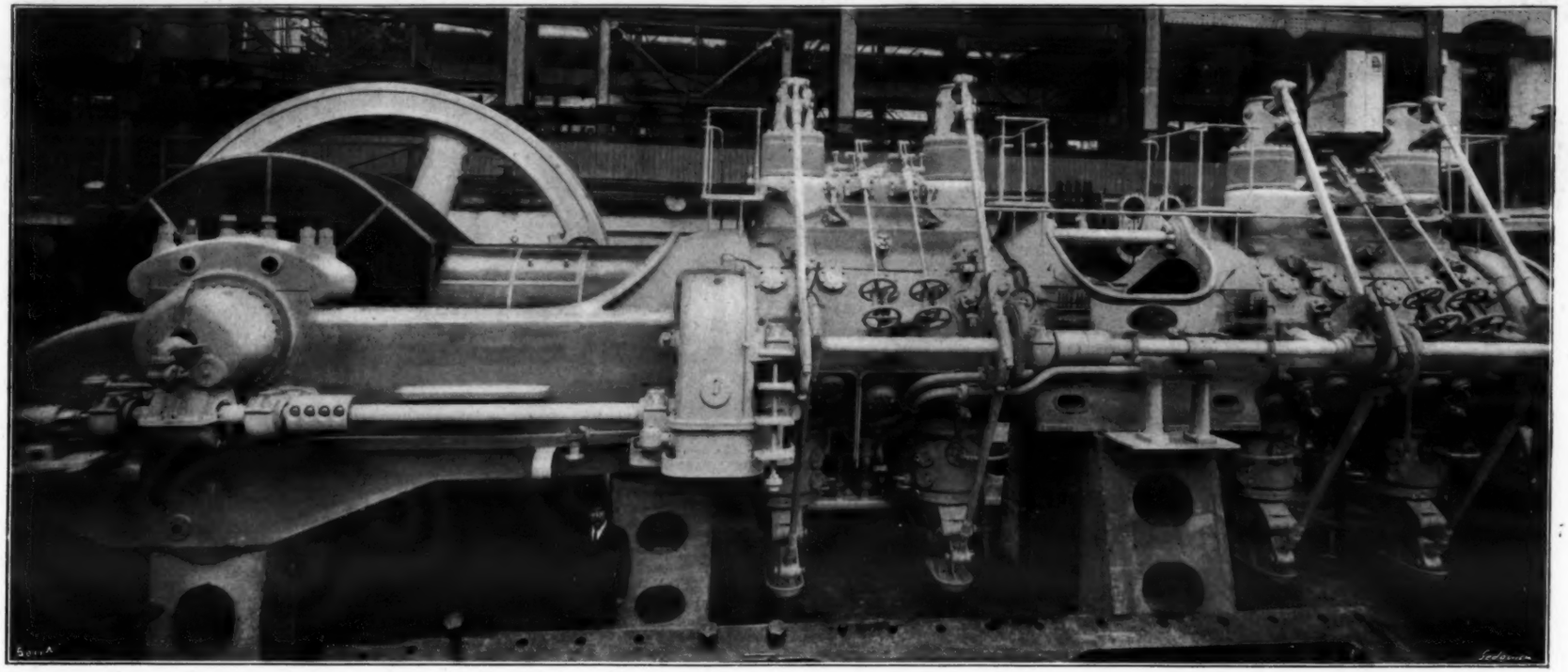
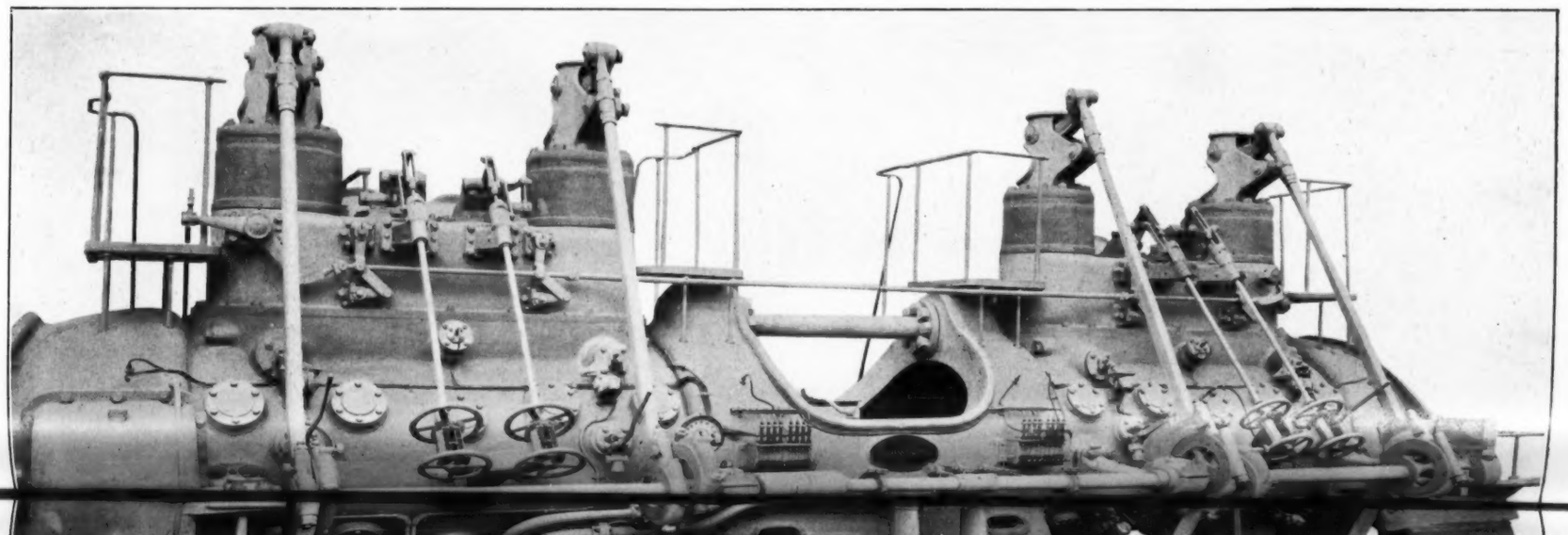


FIG. 1. FRONT VIEW OF ENGINE FOR DRIVING 1,200-K.W. GENERATOR



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With a Two-Page Plate of the GAS ENGINES FOR FRODINGHAM AND APPLEBY WORKS OF THE APPLEBY IRON COMPANY, LIMITED

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In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 583.

ENGINEERING.

FRIDAY, OCTOBER 31, 1919.

THE CONTROL OF INDUSTRY.

MORE than once it has been suggested by various speakers for labour that the present decrease in production per workman in many trades is to be explained by a growing dissatisfaction with the existing basis of industry. The workman is not going to lend himself to a greater output merely to increase the profits of the capitalist. We cannot believe that this idea is the main cause of this serious feature in the industrial situation, but it no doubt has some influence, and the way in which it has been repeatedly put forward by certain labour leaders as an explanation of the fall in output may quite likely have helped to make it a contributory cause to that fall. As examples of the insistence on this matter we may refer to the frequency with which it was brought forward during the sitting of the Coal Commission, and to the Labour Memorandum which accompanied the report of the National Industrial Conference held last February. In the memorandum one of the chief sources of labour discontent was stated to be the dissatisfaction of labour with the whole structure of capitalist industry as it now exists.

An industrial survey over, say, the last fifty years shows a gradually increasing interference with, and authority over, industry by Government, both national and local. Factory Acts, intended mainly for the protection of workpeople, were followed by the definite regulation of certain dangerous or unhealthy trades. Many important services, such as gas, water, and tramways, were largely taken over by local authorities, while others, chiefly the post office and its attendant services, were similarly taken over by the central government. The latest stages are to show a much closer Government regulation of electricity supply than it has ever known before, an entirely new control of transport, a great Government scheme affecting the coal industry from top to bottom, and a probability, in the near future, of a national development of water power. Those who now call for still further control and still further nationalisation presumably hold that all these things are good. This is a legitimate opinion, but it may be suggested that the vital change in the whole basis of society which they stand for can only with safety be made slowly and empirically.

The state of disorganisation in which the whole country finds itself as a result of the war is apparently held by some to constitute a reason for still further nationalisation and still further control. In the sense that interference now might affect private interests less than interference in normal times, there is possibly something in this idea; but to argue from this to fuller Government control and ownership is entirely to misread the situation. The present intentions of the Government form an advance in the direction of nationalisation as great as is at all politic—greater many would hold—and the present business of everyone should be towards bringing the industry of the country as a whole back into its old channels. The first business now is to create some wealth, and the only sure way to do this is to help industry to carry on in the way we all understand, and which we all know is financially sound. This should be the policy of even the believers in complete State socialism. Their ideas, in the end, may or may not be sound, but for the present it is certain that all has been done which it is safe to do in the direction of their wishes.

We do not now desire to argue about the general case for nationalisation, nor even to deal with the Government's schemes in connection with transport and other matters. These latter we have already dealt with more than once, and will, no doubt, have reason to refer to again. What we wish to do now is primarily to insist that the nationalisation of industry has already gone as far as is at all wise at the moment; and, secondarily, to consider if, in other ways than by Government interference, some of the labour aspirations which we have referred to may be met. Although we think the effect of these aspirations on labour troubles has been exaggerated by some labour leaders, none the less they have some effect, and in any case the aspirations in many directions are legitimate. Organised labour and the working man individually are each calling out for some greater control over their own industrial destiny than they have at present, and it is, even on the lowest scale, politic to enquire if this greater control can be given in some other way than by embracing the doubtful benefits and the admitted evils of nationalisation.

This matter has been the subject of much general attention of late, and various definite suggestions have been made. One of the more important of these was the Government's offer of one of the national shipyards to one or other of the great trade unions. That this offer was not accepted was in some ways matter for regret. We say this in good faith. It is to be feared that in some quarters the embarking of the unions in industry in this way was encouraged for the satisfaction of seeing them make a mess of it. That, however, would have been of no value to anyone. The advantage of the experiment would have been that some little further light might have reached the working man on the subject of the difficulties of modern industry. Some union, or some section of some union, might have learned something of the hampering effect of an unsettled labour and the folly of a deliberate attempt on the part of the working man to restrict his output. We do not imagine the experiment would have been successful, but it might have taught useful lessons.

Another suggestion which has been made towards the greater participation of labour in the control of industry is that manufacturing companies should admit representatives of the unions to which their workers belong to seats on the Board of Directors. In the case of the Ebbw Vale Steel, Iron and Coal Company, such an offer was definitely made to one of the unions. It was, however, refused. This refusal is less easy to understand than that for the taking over of one of the national shipyards. No capital would have had to be risked, and in the event of the labour director being dissatisfied with the policy pursued, he could always have resigned. We fear this incident suggests that organised labour, while claiming a greater part in the control of industry, is in many cases going to avoid shouldering the responsibility which such greater control necessarily carries with it. This is a vital weakness, and if it persists, labour can never take any important part in the control of industry. An aspect of the same weakness has cropped up more than once in connection with profit-sharing schemes. Labour has at times shown itself quite prepared to accept the profits, but has shown no equal readiness to help carry the losses.

Labour can have no part, and should have no part, in the running of a commercial business unless it is prepared to take the evil with the good. Certain firms may be in a position to give a proportion of their profits to their workpeople in the form of a bonus, or, what comes to the same thing, may earmark the dividend on a proportion of their shares for distribution among their employees. If the firm makes a profit the workpeople benefit; if it does not, they are no worse off than before the system was inaugurated. This scheme may do good and lead to better work in the shop, but in no sense does it constitute any control of industry by labour. Let it be suggested that instead of the return on the earmarked shares constituting a bonus, it should form part of the normal wages of the employees. If the firm did well the employees' wages would be high, if it did badly, they would fall below standard. It need not be said that this

scheme would not be accepted by any body of employees, and rightly. The commercial success or failure of a manufacturing firm is not within the control of its workpeople, and in no fair sense should their remuneration depend on a commercial policy which they do not dictate. Theoretically, the difficulty might be overcome by arranging for the workpeople to appoint a director to the Board; but even then it is quite certain the scheme would not be agreed to. Apart from the practical difficulties of working the arrangement, the workpeople would never be prepared to delegate the control of part of their wage to the commercial ability of any representative or any board of directors. In this they would show less courage than capital daily shows, but we believe there is no doubt about the fact.

One aspect of the question of the control of industry by labour which we have never seen referred to is the fact that there is nothing to prevent, and for many years has been nothing to prevent, labour of its own initiative obtaining a measure of such control. The greater part of our industry is in the hands of limited companies, and the ultimate control of those companies is in the hands of the shareholders. If workpeople are prepared to buy shares in the organisation which employs them, they will at once obtain some control of the management. The obvious reply to this is that the individual workman has no funds to invest, or at any rate that his funds are so small that he dare not risk placing them in a speculative business. A further point is that even if he purchased shares, his holding would be so small that he could exercise no effective control. This latter difficulty might be overcome by unions raising a special fund for investment in industry. There is, of course, no likelihood of such a thing being done, and it is fairly certain that working people and unions have no intention of risking their funds in this way.

This brings us back to the point from which we started. If labour is not prepared to face the risks and responsibilities of industry, it cannot control it. This is the essential weakness of the syndicalisation schemes which have been put forward in connection with the coal industry. Straightforward nationalisation is at least a logical proposal. The whole nation goes into a business, and, if it fails to pay, the loss falls on everyone. Syndicalism proposes, however, that labour should take a large part in the management, but in case of failure should carry no part of the loss. Such a state of affairs could not stand, and an experiment in syndicalism would end in nationalisation. It is useful to remember that the carrying on of a manufacturing business in this country is a purely voluntary occupation. The capital which backs the business is not bound to employ itself in that way, and if it is not to be free to manage its own affairs nothing is more certain than that it will cease to so employ itself. We do not imagine that capital would, or could, be withdrawn in six months, or six years, but the mere ceasing of the inflow of fresh capital to industry would be sufficient to paralyse the country.

Although we said above that in many cases the aspirations of labour towards a greater control in industry were legitimate, none the less we fail to see how control in the proper sense can be obtained until labour, or a section of labour, is prepared to go to capital with a logical proposal to go into business together in a proper way, each contributing something, and each facing alike the good times and the bad. We are not hopeful of any such proposal. The aspirations of labour may, however, partly be met by giving it a greater control of the conditions of employment than it has at present, and by giving it a greater insight into, and, consequently, a greater interest in, the industry by which it earns its living. These possibilities were well put in an able pamphlet on the control of industry recently issued by the Federation of British Industries. The pamphlet points out that real control, that is control of the commercial policy, of a business by the labour employed is not practicable, but recommends that workers should be given "the fullest possible voice in the determination of the conditions under which they are employed, provided they do not encroach upon the operations of the commercial management, or lessen the proper authority of the foreman." It suggests that these objects can best be obtained through national and district industrial councils, as recommended in the Whitley Report. The pamphlet also suggests that workers "should be given a better insight into the industry which employs them." It is pointed out that it is difficult to suggest definite arrangements by means of which such a programme could be carried out, but apparently it is considered by the Federation that a good deal might be expected in this direction from the work of the national industrial councils.

LABORATORY TESTS OF MINERAL OILS.

If it were not for valuation and standardisation, the engineer might well leave the intricacies of oil testing to the chemist. As matters are, however, the engineer may receive discordant reports, concerning the viscosity, flash point, water percentage, acidity and calorific value, quite apart from details of constituents, of one and the same oil from different chemists, all of repute and experience, and the engineer cannot simply hold aloof from discussions of oil standardisation. The problem touches him as directly as that of the standardisation of iron and steel. In that case chemists and metallurgists agreed before the war to standardise the compositions of certain representative samples, specimens of which were to be distributed in order to enable chemists to check their own analyses by their own methods. The fact that the necessary investigations of the available methods are still being continued, though the analysis of iron and steel is an old-established science, speaks against the alternative, and apparently simpler plan, to standardise the analytical methods. To standardise methods may mean to stereotype errors; after all, one might say, our safety in trade, in traffic, in science, lies in competition. For such considerations the Institute of Chemistry, in conference with cognate institutions, decided in a kind of compromise last summer to make provision for the preparation and issue of authoritative samples of chemical substances such as to satisfy certain analytical conditions, without, however, restricting the choice of methods which should always be revised.

In the case of oils both the two chief methods mentioned involve considerable difficulties. A few ounces of a steel, which are easily transported and stored, suffice for a complete analysis; the oil analyst wants at least a quart of oil, weighing several pounds, and the distribution and storage of large numbers of these specimens would be a troublesome matter. On the other hand, it is more easy to advise working after a certain method than to ensure its being observed. There are certain knacks and modes of operation which no description, however detailed, can explain, and which can only be learnt by personal watching. In intricate analytical work the chemist naturally prefers to adhere to his own ways, not infrequently from distrust of his own capability rather than from over-confidence. When the Institution of Petroleum Technologists discussed a paper on the Testing and Standardisation of Motor Fuels two years ago,* Mr. Alexander Duckham proposed that the Institution should appoint a Standardisation Committee to investigate methods of testing. Definite steps were not taken at that time. When the question came up again last Tuesday before the same body, Mr. Arnold Philip, B.Sc., F.I.C. (Admiralty chemist, at Portsmouth), took the same line in his paper on "Some Laboratory Tests on Mineral Oils," and it seems indeed that at present little more can be done than to devise and to improve methods of testing.

Mr. Philip did not attempt to deal with the vast range of oil testing. There was no organic chemistry in his paper, if that phrase be permissive, and his chief points were equally interesting to the chemist and the engineer. The first point is, of course, sampling, about which books have been written in every branch. The bulk sample must be large. The one constituent never absent, and yet an accidental impurity, water, may be visible or emulsified with the oil or tar, dissolved. Mr. Philip mentioned that he always presents his results as obtained on the oil as separated from any visible water or emulsion, and he described first how the visible separated water may simply be determined with the aid of settling flasks and pipettes in the two cases that the liquid (petroleum, shale oil or tar oil) is either lighter or heavier than water. We shall presently come back to the water question.

The second point discussed was the distillation test for separating the crude oil from the petrol spirit, kerosene, gas oil, lubricating oils, &c. No fractionation method being known by which two or more mixed or dissolved liquids can be completely separated from one another, some routine test has to be accepted as in so many other branches of oil testing. Mr. Philip effects the distillation tests in two stages, both with the aid of partly novel apparatus. In the first operation about 1 litre of the oil is submitted to a topping distillation at 260 deg. C. (500 deg. F.), which yields the petrol, water and kerosene together. The glass flask is surrounded by a heating coil of copper, and air is sucked through the liquid at the rate of 2·4 cub. ft. of air per hour by an electrically-driven air pump; there is a water-cooled condenser, and the air returns from the receptacle, into which the liquid drops, to the coil and to the liquid of the flask being kept in circulation. A novel gas-current meter forms part of the device, which was described as being quicker and safer than other apparatus. The second operation is carried out in another vessel; it is made of copper or iron and consists of two cylinders, the lower, smaller cylinder fitting into the upper, larger vessel in such a way that an annular gutter is formed for the heavy oil vapours. Gas or superheated steam may be passed through the still, and two conical perforated hoods in the lower cylinder prevent any volatilised oil from returning into this part, though they may collect in the gutter. Mr. Philip gave particulars of distillation tests carried out with these appliances by himself and by four independent experienced experimenters. Though agreeing as to some results, the five experimenters differed very much as to the amount and the melting-points of the wax obtained. Some of these discrepancies may be sufficiently explained by the different methods of estimation and the different temperature ranges used by the experimenters; but one cannot help feeling that the discrepancies observed also demonstrate the difficulties of the distillation test.

As regards the distillation of motor spirit the general preference is for spirit containing large proportions of the high-boiling fractions, and in the tests much depends upon the dimensions and arrangement of the apparatus and on certain conventional practices. The initial distillation-point, *e.g.*, is sometimes defined as the temperature at which the first drop of condensed spirit falls from the thermometer or from some other part of the apparatus. This, of course, is unsatisfactory, and Mr. Philip proposes to determine the temperature at which the vapour pressure of the spirit balances the atmospheric pressure, by means of an apparatus of the ordinary U-tube kind.

The determination of the calorific value of the spirit he would perform in a bomb calorimeter, placing the spirit in a loosely-stoppered or sealed tube and bursting this tube by electrically firing a little naphthalene which is put in the same platinum tray together with the tube. The troublesome distinction of "high" and "low" calorific fuel values he is inclined altogether to abolish; at any rate, he prefers the Continental to the English practice in this question. The points which he discusses at length may be recapitulated. The high gross value indicates the total heat units evolved in the bomb test of a fuel. For engineering efficiency tests the low (net) value is calculated, in France and Germany, by deducting from the high value the latent heat at 100 deg. C. of the steam formed by any water in the products of the combustion, and in England by further deducting the heat given out by cooling this steam down from 212 deg. F. to 60 deg. F. Mr. Philip shows that the Continental figure to be deducted would amount to about 396 British thermal units for coals, to 1,111 British thermal units for heavy oils, and to

* See Engineering, October 19, 1917, page 420.

1,056 British thermal units for motor spirits, and that this term can generally be allowed for (by arbitrary constants) in the case of coals and oils, but not for creosote and motor spirit; the further heat carried away by the steam due to the hygroscopic moisture of the fuel rarely comes up to 0·4 per cent. and may be disregarded. What Mr. Philip would determine, to remove any ambiguity, is the high (gross) value and the water value, i.e., the total number of units of water weight representing the sum of the water derived from the oxidation of the combined hydrogen in the unit weight of fuel and of the moisture in it. He described a Mahler-Kröcker bomb which he has devised for this "water-value" determination.

The total amount of water in oils and tars was, in America, prior to the war, determined mostly with the aid of a centrifugal apparatus; during the war another method is said to have been developed. Mr. Philip had so many breakages of the glass vessel in the centrifuges that he adopted, years ago, another apparatus for general moisture determination. This apparatus, which is not simple, is a conical copper flask through which air is drawn by a filter pump, and the water vapour is condensed by the aid of a freezing mixture; to avoid frothing the oil is mixed with pumice stone or sand. Mr. Philip did not recommend this method for the rapid testing of power alcohols which might become necessary if the law should be passed that the ratio of water to alcohol must not exceed 1 : 9; in that case the water might have to be salted out or to be absorbed by anhydrous copper sulphate.

Finally we may refer to the effect of the moisture on the flash-point of the oil. The same oil will not flash at the same temperature when dry and when wet. The fluctuation is particularly marked in repeat tests and is unimportant for low-flash oils; for these (flash-point below 120 deg. F.) the rule is in some countries (India, Germany) that, when repeat tests do not differ by more than 2 deg. F., the average figure observed may be accepted. But for higher flash-points very much larger differences (up to 22 deg. F. in Mr. Philip's tables) may be observed, and the question arises whether the flash-point should be determined both dry and wet. As there is no method of drying the oil without changing its constitution by the evaporation of other constituents, and as the oil is used in the wet condition, Mr. Philip advocates performing the flash test on the oil as it is. There is another reason; though the presence of water seems to make the flash tests more discordant than they are generally, and though the drying raises the flash-point, it is by no means certain whether this elevation is due to the loss of water or to the loss of other vapours. In fact, the addition of water to dried oils raised the flash-point in some experiments. To avoid disputes, Mr. Philip would raise the minimum flash-point for oil fuels (150 deg. F. in the mercantile marine, and 175 deg. or 200 deg. F. in the Navy) by, say, 10 deg., and would allow a tolerance of 10 deg. F. The oil itself can hardly dissolve more than 0·03 per cent. of water, and the other water is present in minute or fairly large globules which are very difficult to remove and which would account for the irregular fluctuations of the flash-point.

These researches on the flash-point leave some questions open. It is not known, either, which of the organic acids in natural oils are responsible for the heavy corrosion sometimes observed, and why these acid percentages vary so much in American oils. There are many other unsolved problems connected with these researches, and on the whole it does not seem advisable to hurry oil chemists into a premature standardisation of their tests.

LLOYD'S REGISTER OF SHIPPING.

Every contribution to our knowledge of the splendid effort made by the mercantile marine and those responsible for its construction and management is welcome, as in the estimate of influences conducing to peace there is a tendency to ignore the work done by such agencies, which are nominally of a pacific character. The report therefore of "Lloyd's Register of Shipping" will be read with great interest. It is true that there is not much that is new in this document, but there is a gathering together of much detail, which shows the great influence of the Society itself and, incidentally, that of the shipbuilding industry.

Lloyd's Register is a world institution, and the figures given therefore embrace shipbuilding in other countries, where there was greater possibility of adding to the mercantile marine than in the belligerent countries, where yards were mobilised very largely to add to the fighting force. It is not, therefore, surprising to note that during the last five years the Society has classed nearly 10,000,000 tons of new shipping. Lloyd's year ends with June, and in 1914–15, which may be regarded as the first twelve months in their records of war operations, the tonnage classed was 1,295,623, which was over 700,000 tons less than in the previous year. In the following year there was a drop to 790,000 tons, which, associated with the extensive destruction of merchant ships, and the utilisation of an enormous number for war purposes, explains in large measure the deficiency in ocean transport facilities. In 1916–17 the total increased to 1,376,125 tons, and in the following year to 2,569,124 tons, while for the year ending June last the total reached the satisfactory record of 3,801,221 tons. The total world's fleet in Lloyd's Register in June amounted to 8,756 vessels, of 21,941,460 tons.

The outstanding factor in Lloyd's records is the position taken now by America. Of the total for the latest year, ending last June, America contributed 470 vessels of 1,883,759 tons, while to the credit of the United Kingdom there was 1,265,036 tons, the measurement of 579 vessels. Japan's total is 355,304 tons, made up by 70 vessels, and Canada's total is 199,941 tons, made up of 87 vessels. Nearly all the American ships are owned by the United States Shipping Board, but the development of shipbuilding plant in the United States is, to say the least, discomforting to those who desire to see the maintenance of the industry in this country at its normal proportion of the world's total output. At the outbreak of war the yards in the United States had an output of about 200,000 gross tons per annum, but at the signing of the armistice there were no less than 140 shipbuilding yards, capable of an annual collective output of about 3,500,000 tons. It is to the credit of Lloyd's Register that they have met the demand suggested by these figures, having in 1916 reorganised their staff, and, with the co-operation of the leading underwriters, shipowners, shipbuilders and engineers in New York, greatly extended their ramifications. The demands, too, were greater in view of the modifications which had to be made to suit American material and conditions. A very large number of fabricated ships were built. The difficulty in finding steel necessitated the revival of the use of wood in ship construction, 426 vessels being built in the United States and 140 in Canada to Lloyd's Register. It is significant that the report states that in "turning out so great a tonnage in so short a period it is obvious that the use of unseasoned timber could not be avoided." A further interesting point is that the greater portion of the steamers for America, and all the wood vessels, were fitted with water-tube boilers, owing to the difficulty of obtaining a sufficient quantity of cylindrical boilers: geared turbines were also adopted. These facts will tend towards the quicker development of the water-tube boiler in the mercantile marine. Already the geared turbine is quickly superseding reciprocating engines. Similarly with the internal-combustion engine, the application of the system has been stimulated by the large number of sailing vessels built in America with auxiliary machinery of this type.

Not only were Lloyd's organisation and surveyors utilised for the increased building of new ships, but the Government utilised their services in many other ways, notably in connection with the construction of standard vessels and of vessels for the Admiralty and War Office. They were responsible for the inspection and testing of raw materials in the United States for the British Government and war material for the French Government, including over 1,400,000 tons of shell steel, for the "condition" surveys of requisitioned vessels and for the survey of vessels surrendered by Germany under the peace terms, as well as for the survey of cold stores.

But much more important was the co-operation between Lloyd's surveyors and the naval construction officers of the Admiralty, particularly in connection with the construction and survey of vessels more or less of the mercantile type, required for special duties in relation to war operations. In conjunction with the Admiralty designs were prepared, the ordering of material and priority of delivery were regulated, and the circulation of plans and information to builders was organised, the whole work of inspection being handed over to the Society's surveyors, who also saw that the details of the specifications were adhered to by the builders. Some of the Society's surveyors were exclusively engaged in securing co-ordination in the construction and supply of ships, material, machinery and accessories, having large powers in the areas of production in which they were engaged. Altogether, 924 vessels of 687,560 tons were built for the Admiralty under the inspection of Lloyd's surveyors. The surveyors have also been engaged since the end of the war in converting trawlers, drifters and other such craft into their peace time condition.

In connection with the incidental work of the Register the committee decided, as a war emergency measure, to allow a reduction in the length of chain cable supplied to vessels, although the size of cable was still adhered to. During the later part of the war the committee sanctioned, for the duration of the war, the omission of kedge anchors, hand pumps and Downton pumps; further, in view of the scarcity of timber, owners were permitted to dispense with the fitting of wood sparring in holds and wood ceiling on tank tops. Owing to the curtailment of the supplies of oil, and to the greatly increased demand for oil for naval and military uses, the idea of bringing oil fuel in the double-bottom tanks of cargo vessels was examined, and, with the adoption of all possible precautions, was carried into effect with great success in the case of a large number of vessels. It may be remarked that even if the necessity no longer exists for the carriage of oil fuel as cargo in the double bottoms of these vessels, the fittings will facilitate the conversion of the vessels to oil burning, if this should be desired at any future date.

On the subject of ferro-concrete ships it is pointed out that special arrangements were made, but only because of the shortage of steel and the scarcity of skilled labour for steel shipbuilding. The vessels on completion, however, were only assigned a class with a special notation of "Subject to Annual Survey—Experimental." The report states that the original building programme of ferro-concrete vessels, which was adopted as a war emergency measure, was reduced on the cessation of hostilities. Considerable progress has, however, since been made with the remaining vessels, about 20 of which have received the Society's classification. In America, also, very few vessels of this type have been proceeded with since the armistice. There are a few building in Spain, Denmark, Norway and the Adriatic.

Four vessels with turbo-electric machinery have been classed by the Society. The largest, the Wulsty Castle, has already been illustrated in Engineering, and, so far as her turbo-electric propelling machinery is concerned, favourable reports continue to be received. The second is the Turbinia, built in Sweden. This vessel also has Ljungstrom turbines. Two smaller vessels have been completed in America, each of 1,370 tons, with 820 shaft horse-power; these vessels are fitted with Rateau turbines. A great increase in the manufacture of Diesel engines intended for submarines and other war vessels is reported, but the manufacture of Diesel engines for merchant vessels did not advance to such an extent as had been anticipated. A table is given in the report showing the advance in the construction of Diesel engines. In 1910 the Vulcanus, fitted with such engines, was of 1,179 tons register, and the engines had six cylinders of 15¾ in. diameter by 23⅝ in. stroke. Since then there has been an almost uninterrupted development to the Glenapp, built in 1918, this vessel being of 7,374 tons, and being fitted with twin engines having 16 cylinders of 29½ in. diameter, with 43⅓ in. stroke. There are now 69 vessels in service, fitted with Diesel engines, constructed according to the rules of the Society. The committee in the report pay tribute to Mr. Milton, the Society's

chief engineer-surveyor, for his "eminent services in dealing with difficult problems in connection with the adoption and development of internal-combustion engines for marine purposes, which have contributed in no small degree to the successful results obtained."

On the subject of experimental research work, the report states that consideration has been given to the subject of the carriage of fluid cargoes, and to what extent such cargoes affected the behaviour of the ship in the direction of increasing its inertia and producing sluggishness. It has been stated on several occasions by different authorities that vessels carrying oil in bulk are more likely to drag their anchors than vessels loaded with ordinary merchandise. During the war it was found that some 12 or 13 of these cases had occurred in vessels carrying oil in bulk, and the inference is that greater stresses had been brought on the rudders than was experienced in ordinary ships. No reason has been discovered for these failures, and the Sub-Committee on Research has arranged for experiments to be carried out at the William Froude Tank at the National Physical Laboratory, for the purpose of obtaining fuller information with regard to (1) the effect of the fluid cargo in the form of oil in bulk on the behaviour of a ship in a seaway, and (2) the manner in which energy passes between the ship and the fluid in the holds. The sub-committee have also arranged for experiments and tests to be carried out by Dr. Marchant, Professor of Electrical Engineering at the University of Liverpool, in connection with electric welding, in order to ascertain the best electrical conditions to be employed in the process of arc welding, and also to determine whether the variations in the current and voltage across the arc during welding can be used as a criterion of a satisfactory nature of a weld after it has been completed.

There are many other indications of the great volume of work done by, and progressive attitude of, Lloyd's Register to be found in the report. We join in the tribute paid by the committee to the work done by everyone associated with this organisation.

POTASH RECOVERY AT CEMENT PLANTS.

At a time when the isolation of Germany was complete and the distribution of potash from the Stassfurt mines impossible, the scarcity of these salts so much needed in agriculture, medicine, and the arts, was severely felt, and existing stocks fetched a greatly enhanced price. The ease with which the deposits of Stassfurt and of Alsace could be worked had convinced the world apparently that competition was hopeless, and a meek submission to the German monopoly was the unfortunate consequence. The acceptance of this position was not justified, for as the Stassfurt beds are simply the product of the decomposition of such minerals as potash felspar, potash mica, and of silicates that abound in the earth's crust, it might be expected that other localities would be no less fortunate than German Saxony, for felspars are among the most abundant of materials, and the processes that led to the formation of these famous deposits are probably at work to-day. Orthoclase and pegmatite contain a percentage of potash not greatly inferior to that of the boasted Stassfurt salts, and of these minerals parts of Scotland are particularly rich, the visible outcrops alone containing many million tons of material. Spain has well-known beds, and these have been actually worked by the Solvay Company, but German influence has known how to restrict the output, and to make this source of little avail. The Italians, too, possess vast stores in Erythrea, with whose working Abyssinian jealousy has hitherto interfered, but this hindrance is likely to disappear. Other localities might be exploited with advantage, for the recovery of the potash presents few difficulties and its reduction to a suitable form has been the subject of many patents. If none of these has been applied commercially, the reason probably is that manufacturers feared the Germans would flood the market, if an attempt were made to interfere with their monopoly. German methods can be very drastic. They did not scruple to restrict the output from Alsace compulsorily, when it threatened to operate adversely to their interests. The mines in the neighbourhood of Mulhausen, if encouraged, could have yielded 800,000 tons per annum; only one-tenth part of this quantity was allowed to come on to the market. In face of such examples of German practice, it behoved patentees and manufacturers to move warily.

Whatever be the explanation, certain it is that when important industries become dislocated for want of necessary materials, relief was not sought by attempting to work other natural resources, nor was one of the many patents utilised. It was well known that potassium chloride, sufficiently pure for technical purposes could be obtained from powdered potash felspar if fritted with common salt. But as far as we know the plan was not tried on a commercial scale. Preference was given to reviving old methods that had been in use long before the German deposits were worked, and new sources were explored in the hope of bettering an intolerable situation, or with the view of freeing manufacture from German domination. Among the schemes suggested as promising was one for recovering potash from the flue-dust from cement factories or blast furnaces. The United States have successfully prosecuted this plan, and the quantity of pure potash (K_2O) derived from flue-dust in 1918 was 1,429 tons. It may be mentioned here that the Americans are producing potash from home resources to an extent that the Germans can hardly view with satisfaction. In 1917, the manufacture amounted to 32,000 tons, and this quantity was increased in the following year to 53,000 tons, while a further addition is expected this year. Canada having felt the necessity of an ample and regular supply of fertilisers in order to maintain the grain production in the prairie states of the West, and stimulated by the success that had attended the experiment in the United States, also hopes to make the waste products of the cement works available as a means of supplying this necessary ingredient of mixed fertilisers. Judging from statistics recently published by the Canadian Department of Mines,* Canada has suffered severely by the withdrawal of the potash importations. The rapid decline in the acre yield of many areas in Manitoba is said to be due largely to the removal and export of essential soil chemicals, chiefly potash salts and phosphates, and to the failure to replace those losses. Be this as it may, Canada is determined in the interests of food production to find a home source of supply for this absolute essential. In the following table the weight of potash salts imported in the year 1918 is contrasted with the average quantity in the five years immediately before the war. The need for a home supply is at once apparent:—

Description.	Average for Five Years in Lb.	Weight Imported in 1918 (Lb.).
Caustic in bulk	450,546	3,341
Chloride (ground)	694,755	126
Bichromate (crude)	384,522	12
Chlorate and sulphate (crude)	8,117,994	485
Prussiate (red and yellow) ..	159,413	160
Pearlash	352,576	180
Kainit and manure salts	655,670	60,000
Nitrate	1,929,747	123,198
Cyanide	836,240	206,370
Bicarbonate	16,276	50

It is not possible to give the actual potash content, or the distribution in different trades, but it is probable that Canada needs 1,200 tons of potassium oxide for fertilisers alone. This is approximately the total quantity that the United States can recover from the waste of the cement mills, but as a matter of fact, this quantity is derived entirely from the small number of cement works who have installed the necessary equipment. It does not seem impossible, therefore, that if the process were generally adopted in Canada, though the total cement production is much smaller, yet with a larger number of contributing firms, sufficient potash might be produced to meet the needs of the fertilisers. It is, however, to be remarked that owing to the keen demand in the States, the firms that have installed a recovery plant have entered into the production vigorously, regarding the potash production as the principal operation, and the cement manufacture in the light of a by-product. With the high price of potash such tactics were possible, but with the return of normal conditions of trade, such a policy could hardly be pursued advantageously, however anxious one might be to escape from German control.

The general process of Portland cement manufacture involves the reduction of the raw material to a fine state of division by grinding. The mixed materials, usually some form of limestone and clay or shale, are submitted to a high temperature, when the carbonates of the limestone are decomposed with the liberation of carbon dioxide, and lime is formed. At a much higher temperature, the lime sinters with the silica and alumina of the clay to form cement clinker. This sintered clinker when ground to impalpable dust forms the cement of commerce. In consequence of these grinding operations much dust escapes into the atmosphere, either from the mill house or through the stacks, in the latter case, accompanied by various gases that carry the volatilised salts of a certain portion of the alkaline metals present in the original raw material. The quantity of potassium salts carried out with the flue-dust and gases varies from 2 lb. to 7 lb. per cement barrel of 380 lb. Sodium and lithium oxides, derived from the alkaline silicates in the raw material are also present, but we are only concerned now with the potash. Of this there will be several salts as various gases exist in the flues, but the most abundant is the sulphate. From an analysis it was found that the dust consisted of 43·65 per cent. of insoluble, and 56·35 per cent. of soluble matter. Of the soluble, 61·1 per cent. was potassium sulphate and 3·89 per cent. of carbonate.

The collection of the dust is desirable on other than economic grounds, for its diffusion may be deleterious to the workmen and injurious to vegetation. For these reasons cement makers have been compelled by the law courts to prevent the escape of dust. The simplest method of complying with the order of the court has been to conduct the dust and flue gases into large chambers, in which the solid material would deposit itself. Another method of retention is that known as the Cottrell system, in which the principle of electrostatic precipitation has been applied successfully. In some plants, a form of water spray has been used for cleaning the gases, but systematic collection was no new thing and the chemical composition of this dust was so well known, that when the supplies of European potash were cut off by the war, the collected material found a ready market. The soluble potash content, however, was not large and the desirability of obtaining these salts in a concentrated form became at once manifest. Some diversity of process was introduced according to the thoroughness with which the potash was removed, for in the earlier practice it was found that no inconsiderable portion of the volatilised potash salts remained in the gases after the heavier dust particles had been separated. Hence two general methods have been devised, one for cleaning the dry gases, the other to effect the same object by means of water sprays and water films. These processes vary in detail, but no general improvement has been brought into practice.

The simplest plan for dry cleaning is effected by passing the gases and waste into large rectangular chambers through long flues connected with the cement kiln stacks. These flues have exhaust fans close to the expansion chamber which discharge the dust and larger particles into the rooms adjacent. Since the area of the cross section of these rooms is very large in comparison with that of the flues, the velocity of the gases in passing into the expansion chambers is lowered, and the deposit of the coarse dust facilitated. Screw conveyers collect the dust and deliver it to a common conveyer, whence it can be carried to the dust treating plant or carried back into the mixer. Adjacent to the dust settling chamber is another with apron walls so constructed that the escaping gases pass several times upwards and downwards over the walls before mixing with

* Canada Department of Mines. Bulletin No. 29. Potash Recovery at Cement Plants. By Alfred W. G. Wilson, Ph.D., Special Investigator for the War Trade Board. Ottawa, 1919.

the atmosphere outside. While moving along this circuitous route the gases are subjected to a fine water spray, which effectually removes the finer material not retained in the expansion chamber. The liquor is sent through a series of conical settlers to remove the dust and then filtered, or treated for the recovery of its potash content when it reaches the requisite strength.

The Cottrell method of collection by means of electrical precipitation is, however, in great favour, and there are no data for contrasting the relative efficiency of the two processes. There are several methods of application according as the dust is recovered in a dry state or in the form of sludge, when the greater part of the soluble matter is dissolved in the water. The more recently introduced and simpler form, known as the "pipe type," consists of a vertical pipe made of sheet steel, about 12 in. in diameter, and 18 ft. long. The high-tension discharge electrode is a single wire suspended vertically along the axial line of the tube. The walls of the tube act as the collecting electrode. The number of pipes or tubes forming a unit may vary from 80 to 240. In operating, the gases to be cleaned are made to pass through the several pipes constituting the unit and are discharged into a common flue below, where a hopper bottom is arranged to receive the dust and deliver it as future treatment may necessitate. The greater portion of the dust is deposited on the collecting electrodes which are cleaned at regular intervals by vibrations set up by striking the pipes with suitably suspended knockers. To avoid interruption of the work two units are used alternately, the stream of gas and dust being directed to a second unit while the cleaning operation is being conducted in the first.

In order to make the removal of the volatilised potash salts more complete, a film type of treater was devised to operate in connection with the electrical precipitation method. In the ordinary type, the treater is so designed that a thin film of water is maintained in constant flow down the faces of the collecting electrodes. A water trough is provided at the top of the treater and the circulating liquid is conducted to the trough through suitable pipes from which it overflows down the walls of the cell, the gas being admitted at the bottom and passing out at the top. A centrifugal pump keeps the water in circulation and to this pump the water is returned after the sludge has been removed from the liquid that has passed over the walls.

The mechanical arrangement of the spray system is fairly simple. Sprays are usually introduced directly into the flues and a special chamber is provided in which the escaping gases are trapped by suitable tiles placed in towers. In another type, flue spraying is followed by a special condenser, in which a portion of the water vapour is recovered, containing more or less of potash salts in solution, and the waste heat available from the condensation of the vapour is used for the evaporation of a portion of the saline liquors. Another group of spray systems employ distinctive chambers in which the flue gases are subjected to treatment with sprays. Usually the chambers are arranged in series, the gases being submitted to treatment in three or four units arranged in series one after the other before they escape. A type of spray chamber has been devised in which the escaping gases after saturation with water are filtered through specially designed filter beds.

Owing to the recent demand of potash in any form, it has been possible to market the flue dust containing the potash salts as it is collected by one or other of the above processes, but under ordinary circumstances it will be imperative to concentrate the potash. Evaporation will be necessary at different stages, and since about 45 per cent. of the heat generated by the combustion of the fuel is lost through the fuel gases, it may be possible to utilise a considerable portion of this waste for evaporating the water from the saline solutions which are circulated in the spray systems. Where dry dust is collected, saline solutions are prepared by mixing this dust with hot water. The digestion operations are carried on in special tanks where the solids are permitted to settle and the liquor removed. In the water spray systems some dry dust will accumulate between the kilns and the first spray chamber. This dry dust is treated with hot water and after settling, the liquor is allowed to circulate by the general spray system. In both the dry and spray systems, the liquors to be evaporated after finally settling are passed through filters. A saturation of about 3½ per cent. soluble potash salts gives the most satisfactory result for the spray system. A somewhat higher percentage may be allowed where dry dust is collected.

Dr. Wilson gives interesting descriptions of the more important installations, all of which exhibit variations in detail. Much of the information he acquired in his visits to operating plants is confidential, and therefore complete descriptions and plans cannot be given. Some firms, however, have been good enough to furnish very instructive details concerning the efficiency of operation. At one centre, the potash in the raw material varied from 1·10 per cent. to 1·30 per cent. The liberation originally secured was about 40 per cent., but this has been increased to an average of 70 and a maximum of 85 per cent. The efficiency of collection of the liberated potash varied between 60 per cent. and 70 per cent: the actual efficiency therefore varied from 42 to 59, or an average of 50 per cent. very approximately. "This efficiency has been attained only after close and careful experiment, and can be maintained only by careful operation." A feature which may greatly affect the amount collected is the difference of potash content in the coarser and finer dust. Where the dust is treated in a series of hoppers, it has been found by experience that the coarser dust contains so little potash that it is usual to return the contents of the earlier hoppers to the raw mix.

It is evident that considerable ingenuity has been devoted to the construction of suitable plant, and very considerable capital invested. It is not so definite that the industry is permanent; more information and more experience are necessary before its position in industry can be determined. The future of the market is uncertain and will depend very much upon the continuation of high prices and these cannot be foreseen. But it must be remembered that the collection of the dust or at least the prevention of its escape to the injury of others is made compulsory by law, and owing to legal requirements in some cases this collection was taken in hand when nothing was known practically about the process, or the possibility of recovering potash salts on a commercial basis. Those firms, who were early in the field, took the risk and bore the expense of experiment, have had their reward. Several paid for the entire cost of installation from the profits of the first year of operation, and those who are in this favourable position believe that they will be able to earn a fair remuneration after the return of normal conditions. The prospects of the venture are not entirely or chiefly confined to the sale of potash, for early operators have a large stock of clinker ready for grinding, which has been paid for by potash sales, and they find themselves favourably situated for handling new cement business, especially for export. Those who have delayed installations are in a much more precarious position, it would be absurd to expect any return commensurate with the early reward, for the advantage of the high markets has been lost, and the question arises whether there is under ordinary circumstances a reasonable prospect of advantageously recovering potash salts at normal market prices, after such an outlay as may fairly be incurred in capital and current expenses.

Of the actual cost of erection and equipment the present report tells us very little, because construction costs were affected by war conditions, and the installations were more or less experimental. It is estimated that a complete potash recovery plant using dry electrostatic precipitation would cost about 30 dols. per barrel of daily cement capacity, a water film treater could be erected at a slightly lower cost. The necessary plant for a water spray system would cost from 30 dols. to 50 dols. per barrel of daily capacity. These estimates are made on the rated capacities of the individual plants, the actual output being regarded as confidential. The sums mentioned would not include the provision of evaporating apparatus to effect desirable concentration. This would entail a further expenditure of 25,000 dols. for a 3,000 barrel mill. One important factor still remains to be taken into account. It has already been mentioned that 45 per cent. of the heat generated by the fuel is lost in flue gases and dust. Some of the waste heat, where a recovery system exists, can be converted into power by the use of water-tube boilers and known methods. This heat is also available for evaporation of the saline solutions. The installation of fans leads to a further saving of fuel by permitting a closer regulation of the draft. At one cement works, before installation of potash plant, the consumption of coal was 96·4 lb. per barrel: this quantity was reduced to 87 lb. after the erection of the additional equipment. The daily operating costs vary considerably. For a 3,000 barrel plant, using a dry electrical treater, the daily additional expenditure is estimated at 48 dols.; for a wet treater using either a water film or spray system, 80 dols. per day.

The prices of potash in 1917 and 1918 were remarkable, but too inflated to furnish any future guidance. In the earlier year the price of potash was 4·46 dols. per unit of 20 lb. In 1918 the price varied from 3 dols. to half that amount, the average price would be about 2·50 dols. per unit. For comparison the present prices of Alsatian potash are given and the quotation from the German syndicate pre-war prices, remarking that these terms apply to the net ton of 2000 lb.

	Per Cent. K_2O.	German Syndicate List Prices, f.o.b. Mines per Net Ton.	French Prices per Net Ton January 5, 1919.	German Pre-war Prices per Unit in Cents.	French Present Prices per Unit in Cents.
		dols. cts.	dols. cts.		
Kainit	12·5	4 76	4 51	38·0	36·0
Muriate ..	50·0	32 10	32 83	64·2	65·6
Manure salts ..	21·1	10 51	9 80	49·8	46·4

Dr. Wilson, the author of the pamphlet, whom we have followed very closely, does not seem to be enthusiastic in recommending the adoption of any method of potash recovery. The problem is one which he submits to the serious attention of all Canadian manufacturers, for "it is obvious that the mill which can produce cement at the lowest cost will be in the most favourable position with respect to competitive business." He is on safe ground when he insists on the importance of preventing the escape of mill dust to the injury of adjoining property. The same dust is injurious to the workmen, and on sanitary grounds its indiscriminate dissemination should be reduced. Further, all recovered dust can be returned to the cement mix. The importance of the exercise of small economies is wisely insisted upon. For "potash recovery, fuel economy, elimination of the dust nuisance, reduction of power costs and more complete utilisation of waste heat, with the consequent reduction of coal consumption and coal import, are all closely related problems that merit careful study."

THE INSTITUTION OF MECHANICAL ENGINEERS.

THE first meeting of the new session of the Institution of Mechanical Engineers took place on Friday last, the 24th inst., at the Institution of Civil Engineers, Westminster, the chair, in the absence of the president, Dr. Hopkinson, being taken by Mr. Henry Davey, vice-president.

Mr. Davey first announced that the secretary had received a letter from the president, in which he stated, with great regret, that under medical advice he was unable to be present that evening. He also expressed his indebtedness to Mr. Longridge, who had kindly offered to read his address.

Mr. Davey next referred to the decease, which had taken place since the last meeting, of Lord Rayleigh, honorary member, subsequently stating that the following nominations by the council for honorary membership had been accepted: H.R.H. the Prince of Wales, Sir Richard Glazebrook, and the Hon. Sir Rajendra Nath Mookerjee. Further, that to fill the vacancy caused by the resignation of Sir Dugald Clerk, as vice-president, the council had

appointed Captain H. Riall Sankey to that office. In consequence of the vacancy on the council entailed by this appointment of Captain Sankey, the council had appointed Mr. Christopher W. James, of Leeds, as an ordinary member of Council, while owing to the resignation of Mr. Robert Matthews, Mr. David E. Roberts had also been appointed a member of council. The officers thus appointed by the council would, in accordance with Article 25, retire at the next annual general meeting, and would be eligible for re-election.

A list of 286 members of all classes elected at the recent ballot having been read by the secretary, and a list of the transferences from associate membership to full membership made by the council having been announced, Mr. Michael Longridge proceeded to read the president's address, of which we give a full abstract on page 593 of the present issue.

On the conclusion of the address, Dr. W. H. Maw, past-president, rose, on the motion of the chairman, to propose a vote of thanks to the president. It was, he said, a matter of very deep regret to the members that Dr. Hopkinson was not able to be present, but he was quite sure that they appreciated—as the president also would appreciate—the admirable manner in which the address has been read by Mr. Longridge. In connection with the address, Dr. Maw signalised three points as outstanding, namely, the importance of works organisation on broad and thoroughly modern lines, the desirability of paying more attention than hitherto to motion study, and the possibilities of development of our Indian Empire. Dr. Hopkinson had given some excellent advice with regard to works organisation, advice which, coming from a man who had himself been a most successful manager and had studied works management for many years, would be received with great attention and appreciation. In relation to motion study, Dr. Maw considered it regrettable that in this country the important hints to be obtained from this method of research had not been so thoroughly appreciated as they ought to have been. Motion study was, however, making progress here, although very slowly; this slowness being possibly due to the fact that the number of men who were able to apply it thoroughly and effectively was small. He was very glad to hear that the training of men capable of carrying out motion study in a really practical way was steadily growing. This was partially a result of the war. Motion study had been applied to the training of disabled men. In many cases it had been of importance to ascertain how men who had not the full use of their limbs could carry out certain operations successfully and with reasonable rapidity, and motion-study apparatus had in many instances enabled such men to do much that they would not otherwise have been able to do without a considerably longer period of training. In conclusion, after directing attention to the fact that Dr. Hopkinson had, for many years, had exceptional experience in the development of India, and had studied the possibilities of that country, the speaker formally proposed a hearty vote of thanks to Dr. Hopkinson for his instructive and interesting address, coupled with their most earnest wishes for his speedy and thorough recovery from his present illness.

Dr. Unwin, F.R.S., past-president, seconded the proposal. It would be unbecoming, he observed, to in any way criticise so valuable a paper, based on a very large experience of the subjects with which it dealt. From the speaker's point of view, the particular feature of the address was the emphasis on the fact that there were now being devoted to works administration, workmen's operations, &c., those scientific methods of study with which so much had been achieved in other directions. It was becoming clear that scientific study was as much needed in the workshop as in the laboratory. He had pleasure in seconding the vote, and he hoped that a period of rest would restore Dr. Hopkinson to his full activities.

The vote was then put to the meeting and passed with acclamation, the chairman remarking that the address would appear in the November number of the Journal of the Institution.

Mr. Davey, before bringing the proceedings to a close, proposed a vote of thanks to the Institution of Civil Engineers for the accommodation they had afforded to the Institution of Mechanical Engineers during the war. This proposal, being duly seconded, was passed with acclamation. The chairman finally announced that the next meeting of the Institution, which would be held at the Institution Building, Storey's Gate, would take place on November 21 next, when a paper by Mr. E. G. Conradi, on "The Present Position of Mechanical Road Traction," would be read and discussed.

NOTES.

The East Indian Railway and the War.

It was in 1915 that the services of the East Indian Railway workshops at Jamalpur and Lillooah were first requisitioned for the manufacture of munitions, says Sir Robert S. Highet, C.B.E., M.I.C.E., Agent for the East Indian Railway, in a pamphlet which he has recently issued. Considerable doubt was at first entertained as to whether the Indian workman who operates a lathe in a railway repair shop, and does not generally work with a micrometer, could attain the high standard of accuracy required in the manufacture of high explosive shells. It is a matter of satisfaction and credit to all concerned that no less than 33 complete sets of gauges for the manufacture of shells were expeditiously turned out in the locomotive shops at Jamalpur, while a total of 54,000 shrapnels and high explosive shells were manufactured at Jamalpur and Lillooah up to the autumn of 1916, when the energies of both workshops were diverted to other important efforts. The Jamalpur shops are the only railway works in India equipped to roll the necessary square bars for making dogspikes, and the fact that 12,000,000 of these latter were made and despatched to military railways in the different theatres of war gives an idea of the great service these shops rendered. In addition, over 1,000,000 fishplates and nuts were manufactured for railways in Egypt, Palestine, Mesopotamia and East Africa. The steel furnace at Jamalpur was also of valuable assistance in the production of steel castings and ingots for Government requirements, and the 3½-ton steam hammers were of great service in the forging of 18-pdr. gun jackets. The joint energies of the Jamalpur and Lillooah shops were responsible for the manufacture of a complete armoured train, also of 118 oil-tank wagons. The Lillooah shops turned out a variety of articles of great service to the military authorities in the matter of railway and road transport; at the same time they had to work at great pressure in order to provide and maintain under severely handicapped conditions facilities for the transport of an enormously increased goods and mineral traffic. They manufactured 24 armoured cars and 43 transport and ambulance cars, and a most notable performance was the conversion and despatch of 50 Calcutta Port Trust wagons for the Mesopotamian Railways in the short space of 11 days, at a period when rolling-stock was urgently required in that theatre of war. The pamphlet from which we quote gives detailed lists and illustrations of the war work carried out in the two shops in question, and their achievement, a most creditable one in ordinary circumstances, is seen to be more creditable still when it is remembered that the imports of raw materials into India had been reduced to a minimum, that the supervising and working staff had been greatly depleted by the call to arms, and that the lines had heavy demands made upon them for the transportation of traffic, demands which they met notwithstanding all extraneous work carried out under special difficulties. The East Indian Railway deserves congratulation upon the very successful way in which they met the situation and upon the very valuable aid they rendered in the great war.

The Tempering of Aluminium Alloys.

Certain aluminium alloys, generally known as duralumin, have become materials of high importance during the war, and they owe their great development to their mechanical properties. Some of these properties are singular and due apparently to the method of tempering. In their recent investigations of these peculiarities Léon Guillet, Jean Durand, and Jean Galibourg (*Comptes Rendus*, September 15 last, pages 508 to 511) made use of a duralumin of the following composition: Aluminium 93·9 per cent., copper 3·7, manganese 0·6, zinc 0·25, magnesium 0·43, silicon 0·58, iron 0·53 per cent.; some of these minor constituents may probably be regarded as accidental. Following the ordinary practice, the metal was heated to 450 deg. C., quenched in cold water and then left to itself. The quenching itself did not seem to change the properties of the alloy to any important extent; but the breaking strength, impact strength, elastic limit and hardness increased afterwards within a day or two, while the elongation and reduction in area were little affected. Guillet and his collaborators looked for some transformation point, but could not find any indication of such point by differential cooling nor by dilatation tests. They then determined the influence of the tempering temperature, and in this they discovered a clue to the peculiarity. The hardness before was 65, immediately after quenching it was 61; it then increased, and here the influence of the temperature, 300 deg., 400 deg., 450 deg., or 500 deg. C. showed. After one hour the hardness was still 61 in all the cases; after 24 hours it was 61, 61, 65, 85 for the four temperatures, after 48 hours the figures were 61, 61, 93, 93. Two points are noteworthy. The quenching temperature itself thus did not affect the hardness in the first instance, the change only became apparent after a day or so, and then only when the temperature exceeded 400 deg. C. No change in structure could be detected, but some further experiments supported the conclusion drawn that the metal returned to the original state, exceeding the original hardness, in fact, when left at ordinary temperature. If that conclusion were right, there should be no change at very low temperature, and it was indeed observed, that specimen of the alloy, heated to 450 deg. C. quenched, and then kept in liquid air remained at the same hardness of 61 for 96 hours, though at the temperature of 15 deg. C. the hardness had risen to 93 in 48 hours. In further experiments the metal was reheated to 15 deg., 50 deg., 100 deg., 200 deg., and 300 deg. C., and hardness determination were again made after 1 hour, 24 and 48 hours; the hardening then took place at a more rapid rate than under ordinary conditions. But the temperature of 300 deg. C. proved injuriously high; in this last case the hardness dropped to 53, and it is hence suggested that temperatures above 200 deg. C. should be avoided.

LITERATURE.

Molecular Physics. By James Arnold Crowther, Sc.D., late Fellow of St. John's College, Demonstrator in Physics at the Cavendish Laboratory, Cambridge. Second Edition, illustrated. London: J. and A. Churchill, 1919. [Price 6s. net.]

In revising the material for a second edition of the treatise on "Molecular Physics," the author finds that the necessary changes and additions are not so great as might have been expected, for the great war diverted the spirit of enquiry into other paths than those that lead to a knowledge of the constitution and properties of the atom or molecule. The period has not been, however, quite unfructiferous as the work of Sir Ernest Rutherford and his colleagues amply demonstrates. The results, so far as they bear on this subject, have now been incorporated, and the structure of the atom in particular is better elaborated. The author may, however, congratulate himself that, if there is little to add, there is still less to change, for this is a proof that he wrote under a wholesome sense of restraint, refusing to indulge in captivating and sensational speculations, that have been mooted or accepted without sufficient proof. It need, however, occasion little surprise, if, in a rapidly developed subject, that admittedly lies on the outward fringe of exact science, and where experiment is exceptionally difficult, immature conclusions had been drawn and facts erroneously interpreted. Whatever progress has been made in laboratories at home or abroad, whatever fresh information has been gained by repeated and varied experiment, has made speculation more cautious, but has not overthrown any fundamental hypothesis. The facts acquired by new methods of attack have only

strengthened the foundations on which the theory of molecular physics has been erected.

The author's official position at the Cavendish Laboratory affords him a very favourable opportunity for describing the work of Sir J. J. Thomson, and the researches which have been carried on under his auspices. It is a great advantage to be able to follow a connected account of the continuous work pursued in one great physical laboratory, to be reminded, or informed, of the successive steps that have given to this method its importance and its success. This does not imply that the contributions of other physicists have been ignored, rather have they been used to suggest new or improved methods of research, and to confirm the results that by reason of the minute entities under examination, tend to elude the imagination. It is a further merit in the author's work, that he is at great pains to demonstrate the certainty of these measurements, which those little versed in the processes of molecular analysis accept with the polite respect due to scientific authority, but believe in their hearts are ingenious speculations that, resting on no real or objective foundation, will in their turn be exploded by later and abler physicists. The hard and indivisible atom of the ancients, or of the original theory, has given way to the centre of force of Boscovitch, and in its turn this has been displaced by the vortex atom of Lord Kelvin. When one is asked to enthrone in place of these simpler constructions, an elaborate arrangement resembling the solar system on an infinitesimal scale, he may be excused if he declines to accept such a concept as final, the more so, as the evidence of its existence rests upon the measurement of quantities that far exceed the limits of microscopic vision. Experiments based on deviations of particles in an electrostatic and magnetic field do not appeal to all, and it is precisely at this point that the clear demonstrations of the author become valuable. For the assent to authority he would substitute the logic of experiment.

As one who has himself taken part in these investigations and knows the relative trustworthiness of experiment in spite of its attendant difficulties, the author naturally insists on the acceptance to the full of the evidence from observed facts, when these have been amply confirmed by accordant results under very varied conditions. For example, the value of m/e or the ratio of mass to the electronic charge is known within very small limits. Whatever the source from which the electrons come, whatever the nature of the gas in the discharge tube, the material of the cathode or the working potential of the tube, the results are so nearly identical that there is no room to doubt the experimental fact. The increase of probability with each fresh determination is so great that it virtually amounts to proof, and it may be safely asserted that e is a universal constant, suggesting that every electrical charge is made up of an integral number of electrons, just as every fragment of an element is made up of a whole number of atoms. Tentatively, the conclusion has been hazarded in some quarters and readily accepted by a public who welcome a definite statement unencumbered by cautious reservations, that all atoms are built up of electrons. It may be said in passing that there are very good reasons for believing that the number of electrons in an atom is quite small, comparable in fact, with the atomic weight or the valency, and that the assumption that an atom of radio-active material contains an enormous number of electrons is a quite unwarranted conclusion founded on early and hasty generalisations. That erroneous notion does not, however, concern us at the present moment. What we wish to point out is that the author is anxious to discriminate between the known and the conjectural. He is as careful to distinguish where the solid grounds of experiment end, as he is to indicate the pleasant fields in which precarious speculation may harmlessly disport itself or the still more dangerous quagmires ready to engulf the indiscreet efforts of undisciplined imagination.

Of course the usefulness of a theory is recognised; a working hypothesis is necessary for the advance of science. A mere catalogue of facts is hardly likely to give birth to an important scientific generalisation. The facts need to be marshalled by the light of some leading idea before they can become fruitful. In the "New Physics," we are likely to suffer from a plethora of working hypotheses, that may prevent the concentration of effort or lead to the following of a false clue. Great heedfulness is necessary because a startling discovery, like the dissolution of the atom, is apt to be regarded as an engine of unlimited potency offering a key to unlock all the secrets of physical phenomena.

The necessity for temperate examination makes Dr. Crowther's book especially valuable, for we need a cautious and trained guide to mark a sure path through the changing theories of modern physics. He does not allow us to suppose that physicists have solved the riddle of the universe, an impression that popular writers have at times unintentionally conveyed. In a few striking paragraphs is pointed out what has been accomplished, and how the field of possible investigation has been enlarged by this new method of research. Molecular analysis has enabled the experimenter to detect with certainty the presence in a gaseous mixture of far smaller quantities than is possible with any other method. Moreover, the atomic or molecular weight of the substance is revealed simultaneously with its detection, while the time taken for each single particle to register its presence and its mass is known very approximately, a point of great importance in the study of the modes and methods of chemical combination and decomposition. On the other side, the new method has its limitations. It is restricted to experiment on gaseous substances, or those capable of exerting a vapour pressure at ordinary temperatures, and a further disadvantage is that an element may exist in considerable quantity in the discharge tube and fail to declare its presence on the photographic plate. This may seem a very modest outcome for a process that was hailed with enthusiasm as proffering a solution of all that was obscure in physics. Speculation outran experiment, and some of the most delightful prospects have been found to be unsubstantial.

Still more trenchantly does the author deal with the unproved hypotheses that have centred round the atom and the discovery of the electron. "It would be idle," he declares "to pretend that we have as yet any theory of the structure of the atom which absolutely and completely sums up all the known phenomena of Science"; and again, "we are not yet within sight of a mechanical or electrical theory of the universe, wherein all the chemical and physical properties of the material universe shall be explainable in terms of the electrons and their motions." This is a sane and just view; it is only discouraging if we have failed to appreciate the nature, or have exaggerated the extent, of the advance.

The main additions to the earlier issue consist of a chapter on the structure of the atom, rendered necessary by the new facts collected in the laboratory of Sir Ernest Rutherford, and the remodelling of the chapter on the chemistry of the atom, in order to incorporate the changes and additions to the theory of chemical affinity, due to the experimental facts produced by Sir J. J. Thomson, by which he has demonstrated the existence of two great and markedly different classes of chemical compounds, distinguished by the sufficiency or non-sufficiency of the forces between two atoms to compel the passage of an electron from one to another. This fact of intra-molecular ionisation, as the process of interchange is called, is traceable in many phenomena, but is of particular interest in explaining the discrepancies that are occasionally encountered in the relation that should exist between the specific inductive capacity (K) of a substance, and its refractive index (n). The equation $K = n^2$ is exactly satisfied in some instances, but in others, not even approximately. It is now shown with great probability that when Maxwell law holds, the atoms in the molecule are unchanged. But where the equation is not satisfied, as in the case of water, ammonia, &c., it may be concluded that the compound is subjected to intra-molecular-ionisation. To pursue the reasoning into the related subject of valency will be found very illuminating.

The chapter on the structure of the atom marks progress in another direction. By a rapid historical sketch we can trace the evidence that led to the abandonment of some daring speculations, that rested on the assumption that all mass was electronic in its origin. The total mass of electrons must be a quite inappreciable fraction of the total mass of the atom containing them. This does not exclude the possibility of the electro-magnetic origin of mass, indeed this view becomes more probable with accumulated facts, and may be well studied in this volume. The picture of the atom now presented places the positive charge at the centre, as a nucleus, about which the electrons may rotate as the satellites that compose the ring of Saturn revolve round that planet. The arrangement of the electrons about the central charge in a stable scheme is a fascinating, but difficult, mathematical problem. Without some simplification that may prove unwarranted, the problem would appear to be insoluble by the accepted principles of classical mathematics and electro-magnetic theory. The results which have been attained are far-reaching and suggestive, but the author speaks very modestly of their accuracy or reality. The proposals of one physicist, who has put forward an arrangement for simple atoms and molecules out of assumed positive and negative nuclei, not unsuccessfully if the assumptions introduced are admitted, the author regards as interesting suggestions rather than physical facts. Such caution is highly commendable, and as we have already urged, will be found characteristic of the entire work. More facts are known than can be explained. The mechanism by which the results are produced cannot be constructed. This is the work of the future, which is increased rather than diminished by the brilliancy of the results achieved. More will be done, for, as the author reminds us, "we are marching with a triumphant army and are not inclined to set any bounds on the extent of our possible conquests in the future."

BOOKS RECEIVED.

Irrigation Engineering. By ARTHUR POWELL DAVIS, D.Sc., and HERBERT M. WILSON, C.G., Seventh Edition, revised and enlarged. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 21*s.* net.]

Modern Engineering Workshop Practice. By HERBERT THOMPSON, A.M.I.M.E. London: Charles Griffin and Co., Limited. [Price 9*s.* net.]

Laxton's Builder's Price Book, 1919. Originally compiled by WILLIAM LAXTON. One hundred and second edition. London: Kelly's Directories, Limited. [Price 4*s.* net.]

Boiler Chemistry and Feed-water Supplies. By J. H. PAUL, B.Sc., F.I.C. London: Longmans, Green and Co. [Price 14*s.* net.]

Commercial Russia. By WILLIAM HENRY BEABLE. London: Constable and Co., Limited. [Price 10*s.* 6*d.* net.]

Principles of Electric Spark Ignition in Internal Combustion Engines. By J. D. MORGAN, Assoc.M.I.C.E., M.I.E.E. London: Crosby, Lockwood and Son. [Price 8*s.* 6*d.* net.]

Electricity in the Service of Man. By R. MULLINEUX WALMSLEY, D.Sc. (Lond.), F.R.S.E. Vol. II, Technology of Electricity. Section III. London: Cassell and Co., Limited. [Price 10*s.* 6*d.*]

A System of Physical Chemistry. By WILLIAM C. MCC. LEWIS, M.A.(R.U.I.), D.Sc.(Liv.). Second Edition. In three volumes, Vol. III. *The Quantum Theory.* London: Longmans, Green and Co. [Price 7*s.* 6*d.* net.]

Manuale Pratico per l'Impiego del Cemento Armato. Ing. ATTILIO ARCANGELI. Milan: Ulrico Hoepli. [Price 6·50 lire.]

The "Electrician" Tables of Electricity Undertakings, containing Particulars of Supply in the United Kingdom, the Colonies and Foreign Countries. 1919. London: Benn Brothers, Limited. [Price 5*s.* net.]

The Marine Oil Engine Handbook. Compiled by the Staff of *The Motor Ship and Motor Boat.* Fifth edition. London: Temple Press, Limited. [Price 2*s.* 6*d.* net.]

The Timbers of India. By ALEXANDER L. HOWARD. London: W. Rider and Son. [Price 2*s.* 6*d.*]

Aeroplane Structures. By A. J. SUTTON PIPPARD, M.B.E., M.Sc., and Captain J. LAWRENCE PRITCHARD, late R.A.F. London: Longmans, Green and Co. [Price 21*s.* net.]

AMERICAN SHIPBUILDING FOR DUTCH INTERESTS.—We read in *International Marine Engineering* that the Sun Shipbuilding Company, Chester, Pa., has received a contract to build a 10,000-ton steel passenger and cargo vessel for Dutch interests. The steamer, which will have accommodation for 2,500 passengers, is intended for Pacific and East Indian trade and as an emigrant steamer from Rotterdam and Amsterdam to Dutch possessions.

15·9-H.P. FOUR-CYLINDER MOTOR CAR FOR THE OLYMPIA SHOW.

CONSTRUCTED BY MESSRS. RUSTON AND HORNSBY, LIMITED, LINCOLN.

(*For Description, see opposite Page.*)

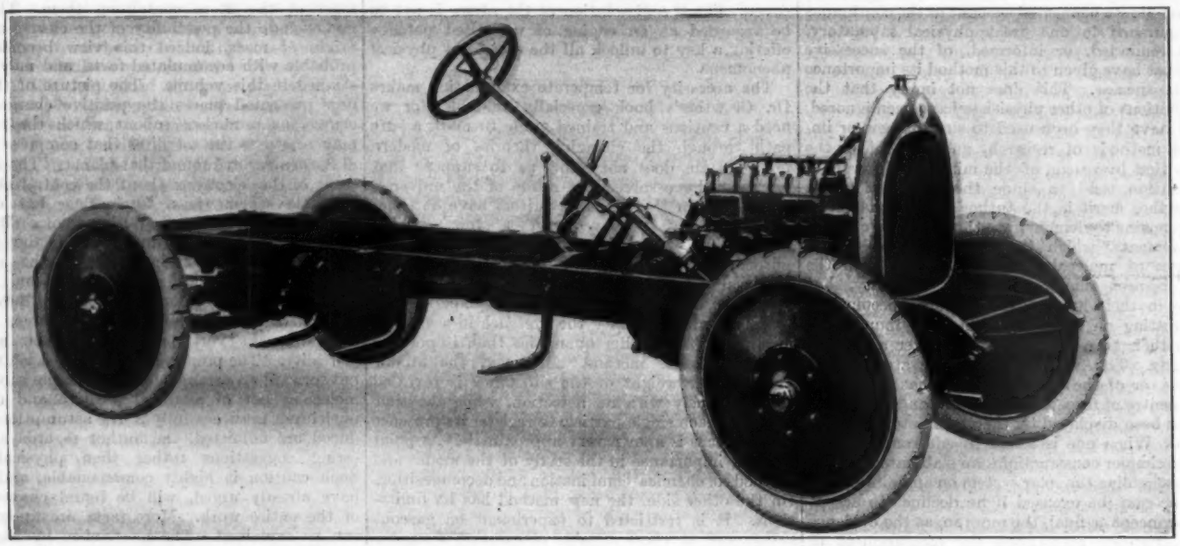


Fig. 1.

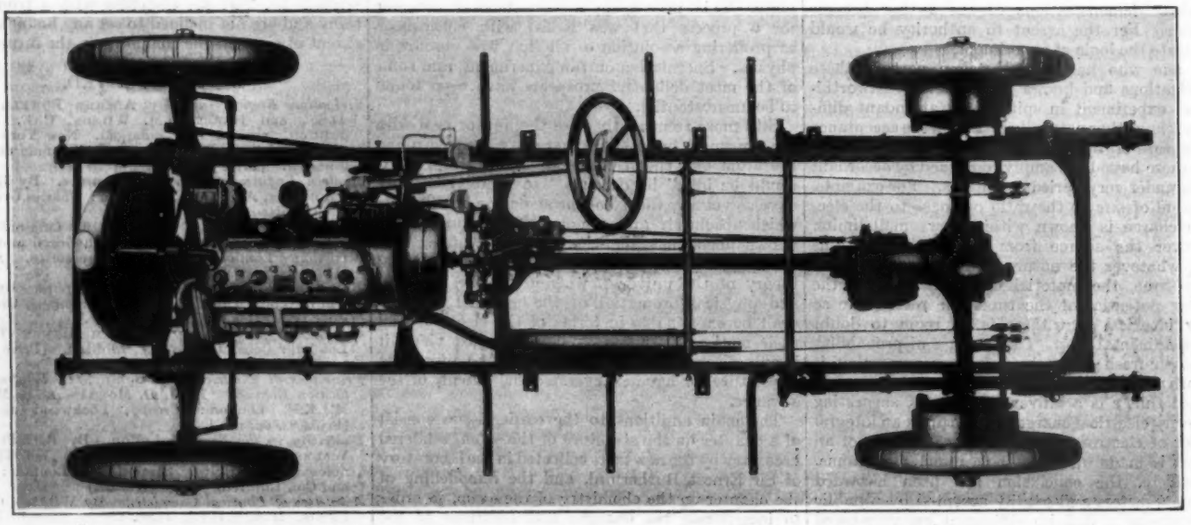


Fig. 2.

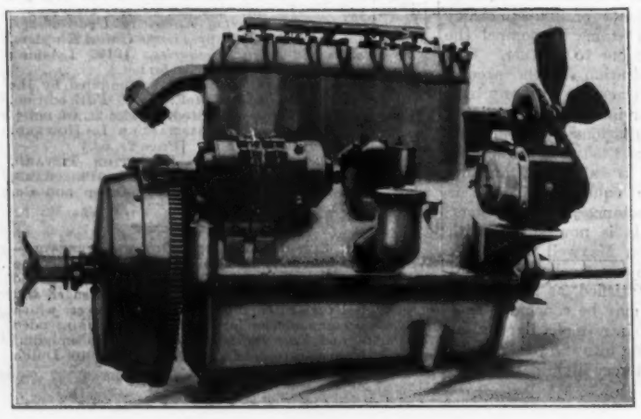


Fig. 3.

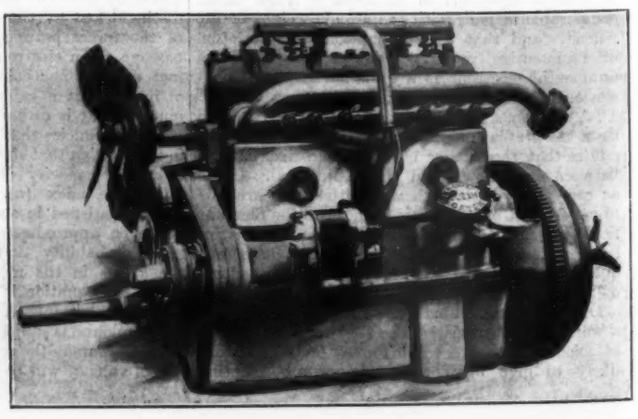


Fig 4.

THE RUSTON-HORNSBY 15·9-H.P. FOUR-CYLINDER MOTOR CAR.

AMONG the new cars to be exhibited at Olympia which are likely to attract considerable attention, those to be shown by Messrs. Ruston and Hornsby, Limited, of Lincoln, may be expected to occupy a prominent place. The excellent work which this firm has done in other and allied branches of engineering makes their appearance in the motor-car world one of considerable interest. Messrs. Ruston and Hornsby's policy is to build a single model so designed as to render it suitable for manufacture on a quantity production basis, and eventually to sell it at a figure enabling it to compete with foreign built cars. The standard car is a five-seater with a wheel base of 9 ft. 9 in., and a 4-ft. 8½-in. track. It is fitted with a four-cylinder, 80 mm. by 130 mm. engine, and is geared for three speeds forward and one reverse. A C.A.V. electric lighting and starting set is fitted.

Considerable attention has been paid in the design to the question of simplicity of manufacture and ease of erection. The unit assembly system has been adopted and the number and complication of parts reduced as far as possible. Steel pressings and stampings have been used largely throughout the chassis and body. As our readers will know, Messrs. Ruston and Hornsby have very extensive facilities for this class of work. The clutch, wheels, radiator shell, dash and panels are made from pressings, in addition to the more usual pressed parts. Four views of the chassis are given in the figures on page 592. From Figs. 1 and 2 it will be seen that the frame is of simple design, the main members being straight throughout their length. Four pressed and two tubular cross-members are fitted. Three-point suspension is used for the engine, the front being carried on a circular housing surrounding the starting handle bracket and resting on the front cross-member, while the rear end is supported by two arms bolted directly to platforms on the second cross-member. The third, or main, cross-member carries the brackets for the change-speed control, brake and clutch pedals, and the attachment for the front end of the torque tube. As will be seen in Fig. 2, the gear-box is carried directly off the back axle casing.

Semi-elliptic front and three-quarter elliptic rear springs are fitted. The rear springs have swinging shackles at both ends. The front axle is a solid steel stamping, and the swivel pins are fixed to the outer end of this. The stub axles are of the jaw pattern, with phosphor-bronze bushes. The steering gear is of a patented design, the movement of the cross-shaft being obtained from the action of two cams. These are of snail pattern, cut from the solid and keyed to the main shaft. Rotation of the steering wheel increases the lift and angle of one cam and decreases the lift and angle of the other. This action is transmitted to the drop arm by two ball races on the steering box cross-shaft. Backlash is practically eliminated, and the wear is said to be negligible owing to all pressure being taken by hardened cams and ball bearings.

The engine which is illustrated in Figs. 3 and 4 is of the four-cylinder type, the cylinders being 80-mm. bore and 130-mm. stroke, giving 15·9 h.p. on R.A.C. rating. The cylinders and top half of the crank-case are cast in one block, the cylinder heads being a separate casting. The valves, of large diameter, are placed on one side and have adjustable lifting tappets. The crankshaft has three bearings lined with white metal and located in the top half of the crank-case. Lubrication is from a gear pump immersed in the sump and driven by a spiral gear from the camshaft. This delivers oil to a filter and from thence to the main bearings, timing gear and troughs underneath the big-ends. Splash lubrication is relied on for the cylinder walls and gudgeon pins, and a pressure-indication gauge is provided. Ignition is by a British high-tension magneto, and a Zenith horizontal carburettor is fitted. Cooling is by pump circulation, the pump being placed in front of the timing case and driven by the same shaft as the magneto. The radiator is of the honeycomb type, having the tube and tank block as a complete unit bolted inside a light-pressed steel casing.

The clutch is of the inverted-cone type, made of two light pressings, the outer one being bolted to the flywheel and the inner one carrying a fabric lining. A single volute spring is used, the tension of which may be varied by means of a split nut and thrust collar carried on the clutch centre. Adjustment is also provided for the position of the clutch pedal. The gear-box, as already mentioned, is carried directly off the back-axle casing, the drive being transmitted to it by a tubular propeller shaft. The upper end of this shaft is coupled to the clutch by a Hardy Canflex universal joint. The torque tube surrounding the propeller shaft has a forked coupling on its upper end and free to work on the tube. This coupling is attached by trunnion pins to a bracket on the main cross-member. This arrangement can be seen in Fig. 2. Short stiff shafts running in ball bearings are used in the gear-box. A speedometer driving shaft is provided in the gear-box cover. It is positively driven from a pinion on the layshaft. The three forward speeds give 7 miles, 12 miles and 22 miles an hour at 1,000 r.p.m. of the engine. A bevel-driven semi-floating rear axle is fitted, the centre being a steel casting having the two tubes pressed and riveted in place. Rear wheel brakes are fitted of the internal-expanding type, with Ferodo-lined shoes. The pressed steel brake drums are 17 in. diameter and proportionately wide, so there is little fear of trouble from overheating or wear. Compensating gear is fitted for equalising the pressure on the rear wheels.

THE INSTITUTION OF MECHANICAL ENGINEERS.

Abstract of Presidential Address to the Institution of Mechanical Engineers. By Mr. EDWARD HOPKINSON, D.Sc., M.P.

I.

To be President of the Institution of Mechanical Engineers is a great honour; it is also a great responsibility. Only those who have served as president can realise how multifarious and exacting are the duties which attach to the office, and how real is the responsibility which their adequate discharge entails.

It has been the custom hitherto for the president to deliver his address soon after assuming office, and he has thus been enabled to take an early and fitting opportunity of expressing his appreciation of the honour conferred upon him. Circumstances this year made it desirable that my address should be postponed from the March meeting to this, the opening meeting of the new winter session. I have thus, before addressing you, been able to gain from my own experience of the last few months a fuller knowledge of the work of my predecessor, Mr. Longridge, who, through two difficult years of war, gave his time and ripe experience in unstinted measure to the service of the Institution. You will permit me, therefore, while thanking you for the honour conferred, to express my sense of diffidence in attempting to follow in the steps of my predecessor.

The Institution emerges from the war period with an increased membership in all grades except that of graduates, though the normal rate of increase in members has not been maintained. Since the conclusion of the war there has been a marked increase in the applications for membership, and there is every reason to anticipate rapid growth in the number of members in the immediate future.

It has been already announced that H.R.H. the Prince of Wales has consented to become an Honorary Life Member of the Institution, thus following King Edward and King George. The council has also elected as Honorary Life Members, Sir Richard Glazebrook, C.B., and Sir Rajendra Nath Mookerjee, K.C.I.E. Though Sir Richard Glazebrook would not claim to be a mechanical engineer, engineering owes a great debt to him for his work as Director of the National Physical Laboratory, which he developed into an essential factor in the process of engineering science. Some of the most important research work undertaken by the Institution has been carried out at the National Physical Laboratory, more particularly the extensive research on alloys and that on hardness tests, which are still in progress. Many of our members who undertook the manufacture of shell and fuses for the first time during the war will remember their despair at the impossibility of obtaining official test and approval of the necessary gauges until the work was undertaken by the National Physical Laboratory, which thereby removed a most serious hindrance to the production of munitions. We observe with satisfaction that by the appointment of Professor Petavel, a member of the Institution succeeds to the post which Sir Richard Glazebrook has just relinquished.

It is also equally appropriate that at a time when the common prosecution of the war has brought the constituent parts of the Empire into closer relationship, the name of a distinguished engineer, who is also an Indian subject of His Majesty, should be added for the first time to our roll of honorary members. Sir Rajendra Mookerjee has rendered great service in the development of engineering work in India, more particularly in connection with light railways, pumping and storage plant for water supply and drainage, and the erection of public buildings and industrial works in the Province of Bengal and also by the interest he has taken in engineering education.

When, more than two years ago, my predecessor addressed you, he spoke in the very midst of the struggle, ever increasing in intensity to its sudden and dramatic conclusion on the signing of the armistice. "The victory we all pray for," he said, "may be won before my successor takes my place." So it has been, and I address you nearly twelve months after the conclusion of hostilities and when peace, if not completely re-established, is so far secured and settled that the belligerent nations can turn from the problems of war to the not less difficult and serious problems of peace. Under such circumstances it can hardly be otherwise than that I should turn my thoughts to some of the effects of the war on the industry and profession whose interests it is the function of this Institution to conserve and promote, and to lessons war has taught us which must be marked and learnt, if we as a corporate body are adequately to discharge the duties of our calling. To quote again the words of Mr. Longridge: "The war has taught us many things, but none more clearly, more insistently than the importance of our engineering industry. Upon this industry we depend for victory to-day, and for security and prosperity to-morrow. Should it be wrested from us, as many industries have been during the past half century, England would fall to the rank of a second-rate power and the British Empire would be dismembered. The war has made us realise the possibility of this great disaster and has brought home to us the need of action to avert it." Now, in the light of fuller knowledge and accomplished fact, we realise, and I believe the nation realises, that our increasing supremacy in mechanical engineering, established as the war proceeded, was indeed an essential factor in victory. Do we and does the nation grasp with equal conviction that if that supremacy is impaired, we cannot hope to solve the problems of reconstruction? We are entering on a new decade which may well prove as difficult and critical as that we are leaving behind. We can achieve success only by years of patient and strenuous work, whose keynote must be the national unity of effort in war translated into our industrial life. Industry must be reorganised with methods, *personnel* and plant more efficient, more productive, and more perfectly adapted to their purpose. As mechanical engineers, we ought to realise that both the direction and the execution of this reconstruction lie largely with us. It is fitting, therefore that we should leave no stone unturned in seeking out and eliminating the causes of our past failures and in finding means whereby we can best satisfy the present and future industrial needs of the country. It is difficult to add anything new to the great mass of literature already existing on these matters. I shall not attempt to do so, and will refer only to certain subjects to which, from my own experience, I consider our attention may be directed with profit.

II.

Administration and Organisation.—If we are to maintain, or perhaps I should say, if we are to prevent further encroachments upon our established position in the engineering world, mechanical engineers must give more attention to the administration and organisation of workshops. We have omitted to realise that to make an efficient machine is one thing, but to make it efficiently another thing. It is no exaggeration to say, for example, that the great majority of British engineering works before the war were utterly unprepared to deal effectively with high-class repetition engineering work. Except in the National Arsenal and a few other engineering works, the system of working accurately to gauges with defined limits and tolerances to ensure interchangeability of parts was almost unknown before the war. Before the end of the war the National Physical Laboratory was testing 10,000 gauges per week.

The exigencies of war have taught us much and have, I think, brought to the fore a considerable number of young engineers of natural administrative and organising capacity. But administration and organisation cannot be left entirely to natural aptitude, even when combined with long experience. There can be little doubt that in the future our shops must be managed by younger men, of more limited personal experience than has been customary hitherto, who will therefore need to rely to a greater extent upon the experience of others, acquired through reading and lectures. These questions of management and organisation are vital matters which ought not to be left to chance and should form part of the specific training of a mechanical engineer.

The full freedom of industries in availing themselves of the new mental material turned out by the technical schools and colleges has been hampered by the innate conservative prejudices of the so-called practical man. The man from the technical schools, however brilliant, could not hope to obtain recognition as a useful member of the administrative staff until he had been through a mill of two or three years of what is designated practical training, during which he could earn no remuneration and might count himself fortunate if he was not called upon to pay a premium for the privilege of working. His heart was often broken by the drudgery of repetition work coming at a time of life when minds are most receptive and fullest of desire to be of use and to absorb new ideas. The war has changed the outlook of the works manager. He has begun to realise that the man who has the advantage of wide reading and of thorough technical training, provided he has a natural practical bent, may make a far better under-manager than the man who has not these advantages, but has spent a much longer time in the workshop. One reason which has militated against the more rapid absorption of the product of the technical schools as an integral part of workshop organisation is to be found in the fact that too little time is given in the schools to teaching the art of production.

The right use of tools and the accommodation of design to the methods of manufacture and to the tools available receive too little attention. Many lectures are devoted to the design and working of a dynamo or steam engine, but few to that of a lathe or milling machine. How often are parts of scientifically correct design incapable of being moulded economically in the foundry or tooled economically in the shop?

Engineers have had an unhappy experience in this respect during the war through having to carry out Government designs, the product of the drawing office without regard to the works, designs unchastened by the necessity of having to hold their own in the world's markets. Yet, I do not believe that it is impossible to inculcate the basic principles of economical production in the class-room, the laboratory and the workshop of the technical school as effectively as, and certainly in a much shorter time than, in the factory. If such subjects were widely taught, the student would soon discover in what direction lay his natural bent and would in his own mind specialise in that direction, and when he came to the

workshop, would be able to show that he could readily absorb shop training in his own specialised subjects and make himself useful therein. If a man, soon after leaving college, can show that he is capable of occupying a definite post in workshop organisation, it will qualify him to pass from one works to another and so to obtain experience of different conditions and methods, and, as is most desirable, in countries other than his own. Happily, the war has done much to break down the prejudice against interchange of experience in the engineering industry, for, where almost all have been forced by circumstances to turn from work to which they were accustomed to other work of quite different character which had to be carried out under pressure of extreme urgency, managers soon found out how much they could help each other, and in responding to the national need came to realise the advantages of co-operation.

Our Institution also has an important part to play in this respect. Much can be done by encouraging the reading of papers which deal with workshop organisation and with production from tools. There has been already a noticeable increase in papers of this character, and I hope it will continue. I do not agree that the discussion of these problems will tend towards advertisement, lower the general scientific status of the papers, or emphasise unduly the purely commercial aspect of works production. A description of the means adopted by a works manager to obtain maximum production of the required degree of accuracy at minimum cost is as important to the progress of mechanical engineering as the description of a new invention.

There is another side of engineering at which it is too often the custom of engineering institutions to look askance, namely, that concerned with the distribution and selling of the product. In most industrial engineering undertakings, the commercial section of the staff is larger than the designing, testing, and foreman section, and it is just as essential to the highest success that it should be composed of trained engineers. A very large proportion of the men who enter engineering works with the intention of fulfilling their calling in constructive work find that they are drafted, through the force of circumstances, to the commercial side, and develop their careers in that direction. No salesman of high-class engineering products can be altogether successful unless he has the engineering instinct and has had a sound engineering training. The successful engineer-salesman must be able to understand and enter into the wants of the purchaser and suggest means for satisfying them. He must also understand thoroughly the properties and capabilities of what he has to sell. It is a common though erroneous idea that a man ceases to be an engineer when he becomes involved in the commercial side of engineering. On the contrary, it often happens that in discharging his commercial duties he is using to the best advantage his engineering knowledge and aptitude.

In a recent paper read before the Institution of Electrical Engineers, entitled "The Functions of the Engineer, his Education and Training," Lieutenant-Colonel O'Meara discussed in great detail the extent to which teaching in the subjects of administration, organisation, and commercial management "indispensable to the complete engineer" should form part of the curriculum of engineering education. His conclusions are based on the fact, too little recognised by those responsible for the conduct of our technical colleges, that in after life a far larger proportion of engineering students find their vocation in the administrative rather than in the technical side of industry.

In mechanical engineering, perhaps more than in any other branch of technical science, the inventor, the designer, and the research worker must keep in constant touch with the workshop organisation. This interdependence should be recognised throughout his college training. For the average man it may be necessary to cut down the hours spent in higher technical work and devote the time so gained to administrative and commercial subjects, and for the exceptional man to postpone some of his higher technical work to a later part of his college career.

Whatever may be the steps taken to widen the curricula for engineering students, it is essential that those occupied in administrative duties should recognise that successful administration is based on principles which are capable of definition and of scientific treatment and analysis, that the accumulated experience of others can be put into a form in which it can be taught and learned, and that those mental and moral characteristics which are essential in the good administrator can at least be developed, if not implanted by training.

We must not, however, be content with teaching only those who are to administer our works and factories. We shall never get the best out of any system of organisation or administration in any field of work unless the workers themselves understand the principles upon which the system is based. A wise manager in an engineering shop will make no changes without first explaining their object to the workers, probably through the medium of the Works Committee. A still wiser manager will so develop the interest of the workers in efficient administration, that proposals for improvement originate with them, and they thus assume the position of having to prove their case. With this in view, it is most important that there should be evening classes in administrative subjects in our technical schools.

Largely due to the experience gained during the war, the need for systematic instruction in industrial administration has been so prominently forced on the attention of those responsible for the conduct of some Lancashire engineering and other industries, that a year ago six firms combined to make an offer to the Manchester Municipal College of Technology to provide an annual sum for the establishment of a special department for this purpose. The department has been constituted and is worked in close co-operation with an Advisory Committee of those who are themselves engaged in works administration. A director has been appointed with three assistants. The objects of the department are stated in the prospectus to be :—

1. To study scientifically all questions regarding industrial management and to collect and co-ordinate the information obtained.

2. To use all knowledge gained with the object of furthering the education of managers, workers and students.

3. To assist in building up a science of industrial administration, and as far as possible to work out its applications to all British industries.

The material side is only one part of works administration ; not less important is the purely human factor. All that pertains to the physical health and mental contentment of the workers is reflected in the efficiency of their work. We have, in many respects, paid far less attention to these matters than the Germans, the Swiss, or more particularly the Americans, but it is significant that the Director of the new Department of Administration in the Manchester College of Technology is a physiologist.

Comparatively little work has been done in England in the quantitative measurement of variations of productive power dependent upon the hygienic conditions of the workshop, and yet in many cases it is possible to establish a definite relation between them. Largely due to lessons taught by war conditions, it has become a recognised practice in well-organised works to appoint welfare superintendents and apprentice masters whose function is to promote healthy conditions of mind and body for the workers. Such officials can abundantly justify their position.

The most important problems in the human side of administration are those connected with industrial fatigue. The efficiency of a man as measured by his capacity for output is dependent upon his hours of work, both in length and distribution, and the integration of the curves connecting rate of output with time of work will show the maximum amount of work which can be obtained from the individual. The investigation of these questions on a scientific basis is of a peculiarly difficult nature on account of the large number of independent variables which affect the result. It may be shown, for instance, that a workman's output is actually greater when working 48 hours a week than when working 53, but such a conclusion may be inapplicable generally because the greater capacity for work may be due not merely to the shorter hours, but to the fact that the shorter hours provide a better distribution of work-time and playtime. For example, the shorter hours may enable the before-breakfast hours of work to be completely abolished, and this may have salutary effects dependent upon quite other factors than length of working hours. Again, to arrive at results capable of wide application, observations must be made over long periods, the object being to ascertain the conditions necessary for the continued maintenance of human effort at its maximum efficiency.

Thus, observations limited in time might show that it would be better to add the hours of Saturday morning's work to the five other working days in the week and thus ensure two clear days, but more extended observation might show that instead of two days' freedom from work in the week, it was better to allow the hours of leisure to accumulate and ensure a month's complete holiday in the year. Another difficulty is the fact that as yet physiologists have not discovered any definite means of measuring fatigue or of determining the state of the body at any particular time with regard to fatigue. Many experiments and much observational work have been carried out with a view to finding such a measure, but with only limited success, and at present the only measure of capacity for work at a given time appears to be the actual rate at which work is done at that time. This is obviously unsatisfactory, because it introduces many factors other than the purely physiological ones of fatigue. It is, for example, a well-known fact that the maximum rate of work does not occur after relaxation. It takes time, as it were, for a man to get into his stride. These are probably psychological effects and not purely physiological.

The appointment last year of the Industrial Fatigue Research Board by the Department of Scientific and Industrial Research and the Medical Research Committee jointly, at the request of the Home Secretary, shows the importance attached to a comprehensive and systematic investigation of these problems. It is the duty of the Board to "Consider and investigate the relations of the hours of labour and of other conditions of employment, including methods of work, to the production of fatigue, having regard both to industrial efficiency and to the preservation of health amongst workers."

The right and economical use of the human labour working a tool has given rise to another line of investigation in workshop administration known as "time and motion" study.

A "best" way can be found of performing any operation dependent upon muscular effort by methodical and scientific study of the various motions involved. For some concrete examples of the advantages to be derived from such investigations I would refer you to report No. 3, published by the Industrial Fatigue Research Board, "A Study of Improved Methods in an Iron Foundry." Before beginning his investigations, the employer in this foundry took the workpeople into his confidence and explained his aims to them. He then analysed the different jobs into their various elemental units. Each movement was studied separately and timed with a stop-watch. All superfluous movements were then eliminated, those which could be performed simultaneously were combined and the tools and material arranged accordingly. On this data he established standard sets of movements and times which were written down for the workmen to learn on cards pinned up over their machines. The application of these principles simultaneously with a reduction of hours and a system of payment involving a higher price per piece as production increased, effected in this particular workshop an enormous increase of output.

As a particular instance of the use of motion study, I may mention the case of a man in the same workshop who for some reason could not keep up with the standard of other men working duplicate machines even although he was most anxious to do his best. It was eventually discovered that he was left-handed, and that evening, after the works were closed, a mechanic altered his machine into what was to all intents and purposes a left-handed machine, and his tools were arranged for left-handed use. The next day he was on time all day, although previously he had been 15 per cent. slow.

Though the actual application of such principles can only be carried out in the workshop and gauged by practice there, the importance of their study and the methods of studying them may well be taught at school or college. Our public schools take infinite pains to teach boys how to get the most out of a cricket bat or an oar with a given amount of muscular effort ; coaching in rowing or cricket is acknowledged to be essential ; why should not our young engineers have similar coaching in the multifarious manual operations of an engineering shop ?

Attention has recently been drawn to another psychological aspect of the labour question in engineering workshops where modern conditions are unfavourable to efficient work compared with those that obtained in earlier days. In the old days, a millwright employed, for instance, in the setting out of a main gear for driving a mill, himself drew it out on the drawing floor, received the wheels from the foundry and set them out for tooling, and finally was usually selected to erect and set to work. From beginning to end of his job he had a clear idea of the ultimate use to which his work would be put, and was largely responsible for it until put into operation.

Thus, he had a real interest in his work as such and must have derived mental satisfaction and encouragement from the results of work well done. An incentive to effort in addition to the mere earning of a wage was ever present in his mind and cannot but have contributed materially to his efficiency. Such incentives have necessarily disappeared under modern workshop conditions, where the workman knows but rarely what are the particular objects to which his work will be applied and what may be the ultimate effect of good or bad workmanship. The turning out of a certain quantity of work which will pass inspection limits his mental horizon and must of necessity induce staleness, lack of interest and mental fatigue. Probably much may be done, even under the stifling conditions of modern repetition work, to impart to the workman a fuller knowledge of the ultimate object of his labour and so to engender a keener interest therein.

III.

Production.—In the foregoing remarks I have tried to indicate a few of the causes which have contributed to arrest industrial development and to point out some of the means which will help us to regain what we have lost. All have one end in view ; to increase our production by greater efficiency in the administration of industry and in the application of labour and by avoidance of waste, whether of raw material, physical energy or human effort. They are based on the assumption that there is a will to work and a desire on the part of the worker to expend his labour to the best advantage. If these are absent, or cannot be engendered, labour itself is vain, and all efforts to improve its conditions doomed to failure.

Though the more far-sighted leaders of public opinion both among employers and employed now realise that only by increased production can we recover from the losses and damage of war, recent events too clearly prove that this truth has not yet permeated all classes. It has been thrust into the background by the demand for the establishment of a higher plane of living for the working classes without consideration of the means whereby it can be obtained. The working classes of this country must be better fed, better clothed, better housed and be able to enjoy the amenities of life in fuller measure than in the past ; they must have more time for recreation of mind and body, and ampler means for promoting physical and intellectual welfare. Surely it would appear obvious that these conditions can only be fulfilled by an increase in the productive power of English industries. This increase in productive power is, *ex hypothesi*, not to be obtained by longer hours of work, but is to be accompanied by shorter hours. Yet labour too has shown itself averse to the tapping of fresh sources of supply by allowing the lower grades of labour to undertake higher and more productive grades of work and by the increased introduction of female labour, not perhaps to the extent that was possible and necessary during war, but to a far greater extent than in pre-war days. War conditions have amply demonstrated with what success both can be accomplished. For myself, I believe the increased production necessary in many industries cannot be attained under the conditions postulated without a change in the application of labour and an increase in the number of those employed. For it must be remembered that increase in production must be far greater than is necessary to meet merely the added home consumption, for, as a country, we produce only a fraction of the raw material we require for our own sustenance and the feeding of our industries, and the deficit must be made up out of imports which we pay for out of our manufactured products.

Thus, it follows that every step in increasing consum-

tion can only be achieved by increasing production in a much larger ratio. It is too often popularly assumed that the higher remuneration of labour will by itself secure an industrial Utopia, and that labour, if it has more to spend, will be able to satisfy its desires. Experience has shown that the very contrary is the fact.

If, as a nation, we are to realise what we all desire, a fuller and happier life for all classes of labour, every proposal for increase or change in the methods of remuneration of labour, every proposal for sharing or redistribution of profits, every proposal for change in control or in the management of industry ought to be subjected before adoption to crucial examination as to whether it will increase production per worker or can be accompanied by other changes in the conduct of the industry which will in their combined effect achieve the same object. Unless they satisfy this test we shall fail in attaining our end. Instead of promoting the welfare of the industry and of those engaged in it, we shall doom it to decay and ultimate extinction. I do not state the problem in this way in any spirit of pessimism. It is rather the reverse—because the problem, I believe, can be successfully solved and that its solution lies largely with the mechanical engineer, provided free play is given to his efforts and that sufficient capital is placed at the disposal of the industry.

India.—I have spoken hitherto solely of the home point of view with regard to reconstruction rather than of those wider considerations which apply to the Empire as a whole. In conclusion, I ask your attention for a few moments in connection with some matters which vitally concern us as engineers in one constituent part of that Empire—India where the problems to be solved are not, as at home, those of reconstruction, but rather of construction.

Until a few years ago, India looked almost entirely to Great Britain for the bulk of her engineering requirements. The engineering world of India, however, is now entering upon a new phase, partly in response to the insistent national cry for the better use of the national resources of the country, and partly because, during the war, India ran serious risk of being largely cut off from communication with Great Britain and has learnt that it is essential in her own interests and in those of the Empire that she should be more self-contained industrially. We may expect, therefore, that in the near future India will be in a position to rely less upon home engineering products, and will supply at least the simpler forms of these products from her own resources. India has already laid the basis of an engineering industry in the establishment of two important and successful iron and steel works. The Bengal Iron and Steel Works, under their present management have been established for some 25 years at Kulti, and have had a chequered career, during which, in 1903, an attempt was made to manufacture steel which proved unsuccessful and was abandoned. The works are now most successful, both financially and in quality of product, turning out 10,000 tons of pig iron per month, about one-third of which is used in their own foundry for the manufacture of pipes, columns and pot-sleepers and chairs. More recently, the Tata Iron and Steel Works have been erected at Sakchi on the Bengal–Nagpur Railway, about 155 miles from Calcutta, and in reasonably close proximity to their supply of coal and iron ore. The works were started in 1912 and have two large blast-furnaces in operation, each capable of producing about 350 tons of pig per day, a third nearing completion, and three more much larger in process of construction. Most of the pig is converted into steel. The rolling mills produce about 120,000 tons of rails and smaller sections yearly. About 13,000 men are employed in the works, adjacent to which a town having 50,000 inhabitants has sprung up, carefully planned in every detail with suitable houses, mostly provided with gardens, for all classes of employees, and schools, institutes and hospital. These two works, even when extended, will not provide more than a fraction of the iron and steel India needs, of which the imports in 1913–14 amounted to over 1,250,000 tons.

At the present time, India cannot roll a steel plate nor draw a steel tube; there are no rolling mills for tinplate or for copper or brass sheets. Lead-piping, galvanised sheets, steel wire, copper and brass rods are not made in India, and no steel castings are produced except on a limited scale at some of the ordnance factories and in a few of the railway works. Even railway axles, carriage springs, wire ropes and chains are imported. No steam-engines of any size are constructed, probably the largest are those of some 400-h.p. for river craft. Portable engines, traction engines and road rollers also are not made, nor steam boilers, except a few of very small capacity. Agricultural machinery, the greatest need of all in India, is not manufactured except to a limited extent in its simpler forms. Substantially no cotton or jute machinery, either for spinning or weaving, is made in the country. Locomotives cannot be built without obtaining many essentials from abroad, and ship-building is in its most elementary stage. Electrical machinery of every kind is imported. Apart from the railway workshops, the principal centre of general engineering workshops in India is Calcutta, but in 1915 there were only 27 of these with an aggregate of 12,000 employees.

Owing to the pressure of war conditions, the situation in respect of engineering industries is rapidly changing. The Tata Iron and Steel Company will shortly have a large plate mill at work for rolling plates up to 1¼ in. thick, and it is proposed to construct a wire mill and a bolt and nut shop of large capacity. Works are to be erected for the manufacture of tea machinery, which hitherto has been entirely imported. Schemes are in hand for the manufacture of agricultural implements in India from Indian steel. Galvanising is being carried on on a fairly large scale by several companies. Such are only a few of many instances of advance.

During the war we have, perhaps unavoidably, lost much ground both professionally and industrially in India. The higher management of the Tata Iron and Steel Works is in American hands and much of the plant is of American origin. The same is largely true of the hydro-electric developments in the Province of Bombay. What I have described with particular reference to engineering industries might be applied with equal truth to many other industries which will develop in the next few decades and which will, each one of them, be dependent upon expert engineering knowledge.

Let me quote some figures taken from the report of the Industrial Commission, which illustrate strikingly the need for greatly increased application of machinery. In British India there are 210,000,000 acres under cultivation, and in 1911 80,000,000 people were employed on the land; one person to every 2·6 acres. The corresponding figures for Great Britain and Germany were one to 17·3 and one to 5·4 acres respectively. The respective standards of yield of wheat and barley in England and India are 1919 lbs. and 814 lbs. per acre for wheat and 1,645 lbs. and 877 lbs. per acre for barley. The explanation of such facts largely lies in the neglect of the application of machinery to agriculture, both in the field and in the processes of preparation of agricultural products. The value of agricultural machinery imported into India in 1913–14 was only about £18,000, and yet India stands third in the wheat and barley producing countries of the world. India produces 3,000,000 tons of raw sugar per year, yet the value of sugar machinery imported is only about £30,000 a year, whereas she imports £10,000,000 worth of manufactured sugar.

It is estimated that there are more than 3,000,000 irrigation wells in India worked by men or cattle and not much more than 1,000 worked by mechanical methods, and yet the use of these in Southern India has shown that small power pumping plant units, either steam, oil, gas or petrol driven, can be most advantageously employed.

It is important for the profession and for industry to note the changing attitude of the Government of India and of the Home Government in regard to the purchase by the former of the material required for Government undertakings. Before the year 1913, the rules of the Government of India for the instruction of purchasing officers empowered to buy stores narrowly restricted purchase in the country itself and required the sending of indents home that purchase might be effected through the Stores Department of the India Office. In 1913, the rules were revised and have been subsequently further modified with the object of giving wider powers to purchasing officers to place orders with engineering firms established in India, whether as manufacturers or as suppliers of engineering material.

The Industrial Commission, in considering the mean they can recommend to the Government whereby it can give direct encouragement to industrial development, have been led to make recommendations of a far-reaching character, some of which are of particular interest to the engineer. I may quote some of these proposals in as condensed a form as possible. Various departments of the Government of India and of the provincial governments such as forestry, agriculture, and the geological survey have on their staff a limited number of scientific officers, each devoting himself to the solution of particular problems which may arise in his department, but forming no part of an organised service and so deprived of the advantages of the prestige and *esprit de corps* and security of merited promotion and means of intellectual intercourse which attach to a Government service. Among these scientific and technical officers are men of the highest scientific attainments whose researches have already resulted in immense benefit to the country, but their numbers are totally inadequate compared to the importance and the number and complexity of the problems to be solved. In forestry, the work of the conservators and the scientific investigations of the botanist and mycologist do not bear their full fruit because there is no corps of trained forest engineers to solve the problems of extraction and transport and preparation of timber for the consumer. There are individual chemists employed in many of the Government departments, but there is no bond of union between them, and the industrialist desiring the assistance of Government in a chemical problem has no means of obtaining authoritative advice.

The report advocates a reorganisation of the existing scientific services so as to unite into one imperial service, classified according to science subjects, all the scattered workers now engaged in the provinces on isolated tasks, a large increase in personnel and the establishment of an imperial chemical service.

The direction and co-ordination of the general industrial policy of the country is to be effected through an Imperial Department of Industries in charge of a member of the Viceroy's Executive Council, assisted by a board of three members, each with a separate group of charges. All three groups will involve the appointment of engineering officers for the discharge of their functions.

There is as yet no base on which to build elementary mechanical training for the Indian artisan. With a people almost wholly illiterate, schools for the teaching of elementary mechanical subjects are useless for the ordinary boy, and in those that have been started it is soon found that the first years must be spent in imparting sufficient elementary education to enable the scholar to derive any advantage at all from vocational teaching. We must look to the workshop itself, not only for training in the particular crafts, but also for such general elementary education and rudimentary technical education as are necessary for the acquisition of craftsmanship. Although a man may become exquisitely skilled in the art of, say, carving ivory, or engraving brass, and remain entirely illiterate, depending upon hereditary genius in his craft, he cannot become a pattern maker or fitter unless he can read and understand a drawing. Wherever schools in direct connection with workshops have been set up, the results have been most satisfactory.

The great railway shops and such other mechanical works as exist in India draw their foreman staff almost entirely from external sources, yet there is considerable material amongst the sons of existing foremen, amongst Anglo-Indians and to some extent amongst Indians themselves, which, with suitable training, might be developed into a useful source of supply within the country itself.

These engineering developments in India must have a marked effect on the professional status of engineers employed in India, which it is incumbent on us as members of the Institution to watch closely and, where possible, to influence for the benefit of our own members in India and for the maintenance of high professional standards.

At the present time there are in India about 600 members of the Inst.C.E., 400 members of the Inst. Mec.E., and about the same number of members of the I.E.E., besides members of various other bodies, such as the Inst. Naval Architects, the Iron and Steel Institute, and various mining societies. There are also, undoubtedly, many qualified engineers in India holding positions of responsibility who are not members of a home society. But India is a vast country, and these engineers are split up into little groups working in places separated by great distances and only aggregated to any extent in such industrial centres as Calcutta and Bombay. Such conditions make anything like corporate life very difficult and deprive the profession of those facilities for mutual intercourse, mutual exchange of experience and access to libraries which have such a large influence on members of the profession living under the more favourable conditions of this country. Efforts have been made in various directions to overcome these disadvantages. The engineers in the Public Works Department have formed congresses in various centres. The members of the Institution of Civil Engineers have attempted to start a branch of their Institution in India. Members of the I.E.E. have more than once endeavoured, but with small success, to maintain a local section of their own. Our own Institution has had a Calcutta and district section since 1910, but it cannot be said to have had an active life, nor to have survived the adverse influences of war. There is a strong and growing feeling amongst our own members that steps should be taken to minimise these disadvantages and develop more corporate life. The members of the Public Works Department Congresses have realised that exclusion of all except Government engineers, which was their policy until recently, was a mistake, and are taking steps to widen their constitutions. Further, it was realised that the Government of India might on many occasions derive advantage if there were a recognised corporate body, representative of the engineering profession, which might be consulted upon such matters as the education and training of engineers, the grants of concession for mining rights or water power, the regulation of electrical supply undertakings, the certification of boiler attendants and similar matters.

The Indian Industrial Commission gave much attention to the various suggestions made to them by engineers in various parts of the country on this subject, and in its report advocated the foundation of a representative society of Indian engineers. It is obvious that conditions in India preclude the formation of individual institutions to represent the various branches of engineering, and that the objects of such a society could only be attained by combining all branches of engineering, whether civil, mechanical, electrical, mining or R.E. The recommendations of the Commission have been actively taken up by engineers of all classes, and I am glad to say especially by our own members in India. The institution of such a Society was decided on at a representative meeting held in Calcutta in December last, under the presidency of Sir Thomas Holland. A committee was appointed to draft proposals for the constitution of the society and rules for its conduct and to consult all the various interests involved. I am informed that all the existing organisations have decided to co-operate in the formation of the new society so that it will embrace and be representative of all professional engineering interests in India. One proposed feature of the constitution of the society is of special interest to us as distinguishing it from our home institutions. There will be a number of branches in such industrial centres as can support them which will be separate entities, largely governing themselves and providing for their own maintenance and the facilities they require, but subordinate to the central council, which is to be located at Calcutta. It is proposed that the same subscription shall be paid to the central council by all members, and the income from these subscriptions, after providing for the general expenses of the Society, will be available for grants to the local associations. The determination as to the qualification of candidates for admission to the society will lie entirely with the central council, on whom therefore will rest the onus of maintaining a high standard of technical and professional qualification. The Council of our Institution has had a copy of the proposed rules sent to it with a request for comments and advice thereon, and the committee of the council set up to consider it have reported that it is the apparent intention to maintain a standard of qualification for membership not less stringent than in our own institution. It was at one time thought possible for the new society to be formed under the auspices of our leading home institutions, but for various reasons such a plan was not feasible, and I think it is generally conceded both here and in India that it is better that the Indian Society, knowing the wants of its own members and the local conditions, should devise its own constitution independently. At the same time, it is, I think, incumbent upon our institution to use its influence in maintaining a high qualification for membership in the Indian Society and to collaborate with it with a view to obtaining the benefits for our own members in India, which such a society can provide.

25–30-H.P. FOUR-CYLINDER MOTOR CAR FOR THE OLYMPIA SHOW.

CONSTRUCTED BY MESSRS. CROSSLEY'S MOTORS, LIMITED, GORTON, MANCHESTER.

(*For Description, see opposite Page.*)

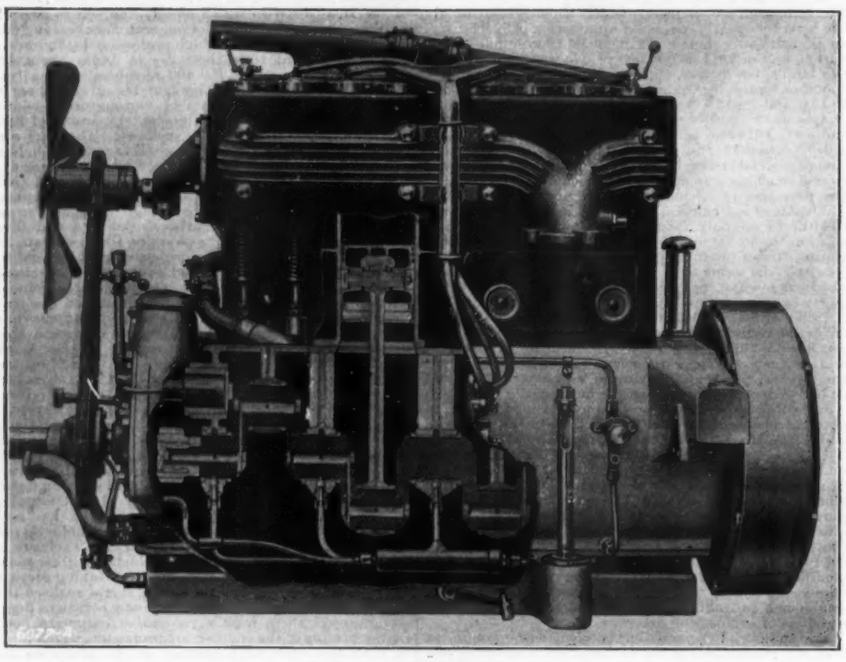


Fig. 1.

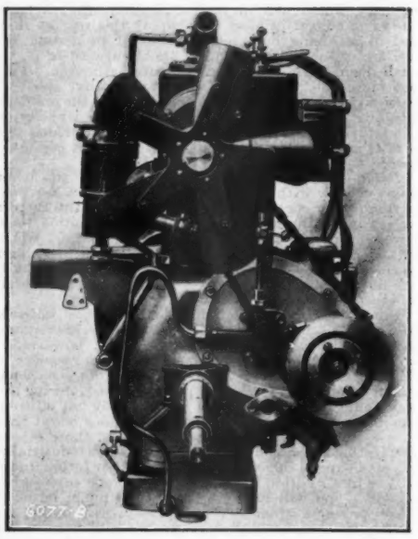


Fig. 2.

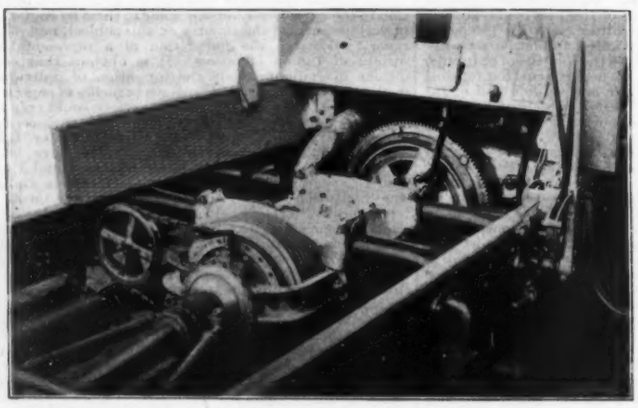


Fig. 3.

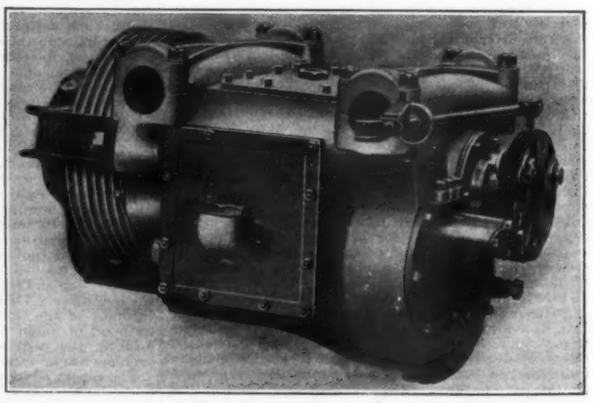


Fig. 4.

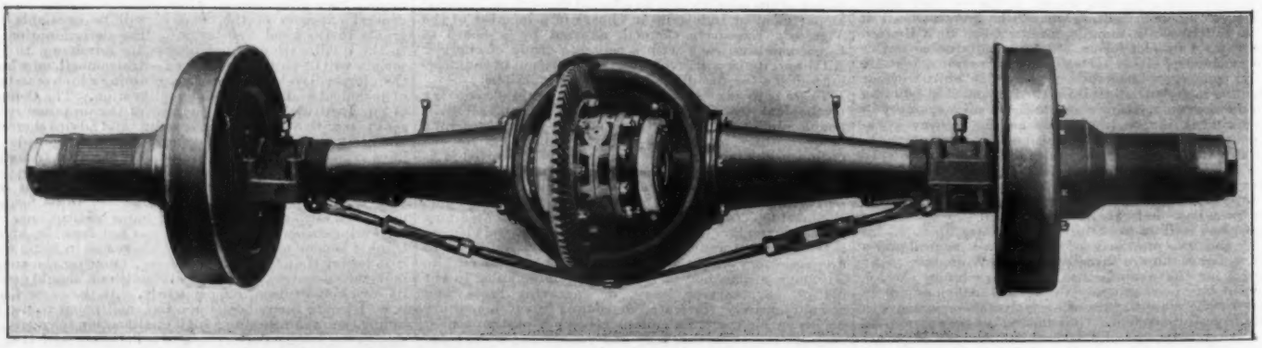


Fig. 5.

THE CROSSLEY 25-30 H.P. MOTOR CAR.

Although we have said elsewhere in this issue that the light car is likely to form an important feature of the Olympia Show, which opens on the 7th proximo, that is not to suggest that the large class of vehicle, the touring car, landaulette, &c., is not likely also to make a good showing. Some of the British makers who in the past have done good work with the heavy or medium class of car have made no attempt to depart from the general lines of practice on which they have been successful in the past, and their exhibit at Olympia will be found to carry on the policy with which their name was associated before the war. Among such firms we think we may put Messrs. Crossley Motors, Limited, of Gorton, Manchester, who are to exhibit examples of their 25 h.p. to 30 h.p. R.F.C. model, equipped with various bodies. The car, which is an excellent example of motor work, has an 11-ft. 3-in. wheelbase and 4-ft. 6-in. track. It carries a four or five-seater body, depending on the type, and has a four-cylinder engine. A four-speed gear-box is fitted. The chassis forms a good example of a British make and design of high-class medium-sized motor vehicle.

We give some illustrations of various details of the car in Figs. 1 to 5, on page 596. Referring to these in the order in which they appear we may first deal with the engine which is shown in Figs. 1 and 2. Its four cylinders, which are cast in pairs, are 101·6 mm. in diameter by 140 mm. stroke, giving an R.A.C. rating of 25·6. The crankshaft is of the five-bearing type, as will be clear from Fig. 1. Plain bearings are used, with pressure lubrication from a pump fixed at the forward end of the camshaft outside the timing-gear cover. This pump is clearly shown in Fig. 2. The engine valves are of large diameter and consequently small lift. They are placed side by side. The camshaft has five bearings and is off-set from the bottom of the tappets, which results in less noise than when a direct lifting action is used, and also enables steeper cams to be employed. The tappets are roller-ended, and the camshaft is totally enclosed in the crank-case. It is chain-driven, the same chain also driving the water pump and magneto shaft. The chain can be tightened by adjusting the position of the water pump and magneto unit on the platform. The carburettor is of the Smith four-jet type with an extra jet added to facilitate starting. It is water jacketed under pressure from the water pump, and can be dismantled without interfering with the water connections. The radiator is carried on the frame of the chassis by ball swivel brackets, which prevent it being injured by frame distortion. An electric starting and lighting set is fitted as a standard. The starter pinion engages with teeth cut on a ring mounted on the flywheel from which it may be easily removed should it suffer damage at any time. This ring can clearly be seen in Fig. 3. A speedometer is also fitted, and is driven from behind the gear-box, as is also shown in Fig. 3.

The clutch is of the internal self-contained type faced with Ferodo. The gear-box is of the four-speed type with shafts running in ball bearings. The box is very substantially carried from two of the tubular cross-members of the frame. This is clearly shown in Fig. 3. The separate view of the gear-box given in Fig. 4 also illustrates the detail of this method of support. The change-speed control is located inside one of the tubular cross-members, thus eliminating any liability to damage owing to frame distortion. The drive from the gear-box to the back axle is through a cardar shaft enclosed in a torque tube in the ordinary way. The rear axle, which is illustrated in Fig. 5, is of the full floating bevel-driven type. The whole arrangement is enclosed, but considerable attention has been paid to making the various parts readily accessible. There are no radius rods from the axle, but strengthening stays are carried from close up to the rear wheel hubs to immediately behind the propeller-shaft brake. These can be partly seen in Fig. 3.

The propeller-shaft brake, of the external expanding type, is foot operated, while hand-operated brakes, also of the internal expanding type, are fitted to the rear wheel drums in the ordinary way. The steering gear is of the worm and worm-wheel type, the gearing being made of case-hardened nickel steel. An interesting method is adopted for taking up any wear which may develop in course of time. This consists of mounting the steering arm shaft in an eccentric bearing, so that when a new part of the worm wheel is brought into mesh with the worm, the wheel may also be raised so that wear in the worm is also compensated for. The suspension is by semi-elliptic springs in front and three-quarter elliptic springs behind. The shackles take their stress in tension and the shackle bolts are lubricated. Rudge-Whitworth detachable wire wheels are fitted. Three chassis will be shown at Olympia fitted respectively with touring car, landaulette and coupé bodies.

THE ACCIDENT TO "K.13."*

By Percy A. Hillhouse, B.Sc.

K. 13 was one of two vessels of the double-hull type ordered from the Fairfield Company late in 1915. She was noticeable on account of her size and method of propulsion, being over 330 ft. in length, of 2,600 tons displacement, and being fitted with water-tube boilers and steam turbines for surface propulsion. For under-water work she had the usual storage batteries and electric motors. She had (Figs. 1 and 2) the following 11 compartments, from forward: Auxiliary ballast tank; bow torpedo room; officers' quarters with fore hatch; control room with conning tower and wheel-house over, and double hatch; torpedo room with torpedo hatch; boiler room; turbine room with two hatches; motor room with hatch; crew space with hatch; steering compartment; ballast tank. On the starboard side of the boiler room was a watertight passage connecting the turbine room and the torpedo compartment. At each end of this passage was a watertight door and, midway, a bullseye looking into the boiler room. There were in all nine watertight doors. She had two periscopes, two wireless masts, two 10-ton drop keels, two funnels, two funnel covers worked by motors and clipped by hand, and four 36-in. boiler-room ventilators having mushroom covers. Her normal crew numbered 52 including officers.

She carried out preliminary trials on December 29, 1916, official speed trials on January 18, 1917, and preliminary submergences at Fairfield on January 6 and January 17. On Saturday, January 20, she carried out a successful dive to a depth of 65 ft. in the Gareloch and remained submerged for about an hour. On Monday, January 29, 1917, she proceeded to Gareloch to carry out her acceptance trials, and made a successful dive to 83 ft., remaining submerged for about 2 hours. All men not required during this dive were put on board the tender, Comet, for lunch. The ship was duly accepted, but as the boiler room had been too hot during the dive to enable the watertightness of the funnel covers and boiler-room ventilators to be checked, another short dive of about a quarter of an hour's duration was asked for and decided upon. The remainder of the party and Mr. Cleghorn and Mr. Macmillan, directors of the company, had lunch; the latter, who had been on board during the earlier dive, went on board the Comet, and Mr. Macmillan had to go ashore to make arrangements for docking.

On board at this time were: Lieutenant-Commander Godfrey Herbert, D.S.O., Captain of K. 13; Commander Francis H. H. Goodhart, D.S.O., captain of the sister vessel K. 14 building at Fairfield, on board to study the working of the vessel; Lieutenant Singer, second in command; Engineer-Lieutenant Lane, engineer to K. 13; Lieutenant (E.) L. C. Rideal, engineer to K. 14; — Pratt, gunner; Petty Officer Moth, coxwain; 48 other naval ratings.—55 naval officers and ratings in all. F. C. Cocks, R.C.N.C., Admiralty representative; F. W. Searle, Admiralty overseer; Frederick Hole, assistant to Admiralty overseer; Donald Renfrew, of Kelvin, Bottomley and Baird; Sydney R. Black, of Kelvin, Bottomley and Baird; William Wallace, director, Messrs. Brown Brothers and Co.; E. Hopworth, Admiralty boiler overseer; W. U. Hancock, Admiralty electrical overseer; Edward Powney, Chadburn's representative; Robert Lake, Brotherhood's representative; Joseph Duncan, pilot—11 Admiralty and sub-contractors' men in all. Fairfield Engine Department: John Steele, foreman; William Smith, foreman; William Lewis, leading hand; William Strachan, leading hand; William Kirk, leading hand; Donald Hood—6 in all. Fairfield Shipyard Department: William McLean, manager of submarine department; E. J. Skinner, manager of electrical department; Frank Neate, his assistant; William Struthers, assistant manager on K. 13; Frank Bullen, assistant manager on K. 13; John Green, head foreman mechanic; Henry Kerr, assistant foreman mechanic; Percy Hillhouse, naval architect—8 in all.

On board at the time of diving there were thus: 55 naval officers and ratings; 11 Admiralty and sub-contractors' men; 14 Fairfield officials, standing-by only, the ship being worked entirely by her own crew—80 persons in all.

The day was fine and balmy, there was no wind, and the tide was high. The vessel lay near the shore a short distance from Shandon Hydropathic, and as she began to trim for her dive, with all the crew at diving stations, the Comet was proceeding towards Shandon Pier. The hatches were all closed, and so reported, and the illuminated signal "Engine-room Closed" signifying that hatches, funnels and ventilators had been closed down, was seen to be so set, by those in the control room. Captain Herbert, after a last look round, closed down the conning-tower hatch and ordered half-speed ahead on both motors. When a suitable position had been reached, opposite Shandon Hydro, he gave the order to submerge, the hydroplanes were set to diving angles and the vessel gradually sank below the surface.

Almost immediately, those in the control room became aware that something was wrong, as the depth gauges showed that the vessel was sinking much more rapidly than was intended. Our ears became oppressed and deafened, showing that the air was becoming compressed. Orders were at once given to blow all tanks and come to the surface. In spite of this the vessel continued to sink rapidly.

Things now began to happen in quick succession. Orders were given to close all watertight doors and to let go drop keels, this being the first thing that made us realise that the matter was a very serious one. Mr. Hopworth was in the boiler-room passage when submergence began and, through the bullseye in the side of the passage, saw water pouring into the boiler room. He rushed first to the engine-room and then back through the passage towards the control room to report this, and was one of the last men to get through the watertight door between the passage and the amidships torpedo room before it was shut. Mr. Struthers, was actually the last man to pass through before the door was shut; in fact, the closing of the door was delayed for a few seconds to let him through. Two men were shut off in the amidships torpedo room.

Three voice pipes led from the control room to the after portions of the ship, and the valves on these were closed as quickly as possible, but before this could be done, a jet of water came through one of the pipes and, discharging on to the switchboard, caused short-circuiting, bursting of fuses and ignition of cables. The control room became filled with white choking smoke. A sack was hurriedly pushed into the voice pipe, to stop the rush of water until the valve was closed. Meantime, the depth gauges showed in quick succession 20 ft., 30 ft., 40 ft., 50 ft., and finally 55 ft., when the vessel came gently to rest on the bottom with a slight list to port and an inclination of about 4 deg. up by the bow (Fig. 1.) The depth was afterwards found to be 64 ft. to the gauge corresponding to a pressure of 28½ lb. per square inch; 55 ft. means 24½ lb.; the difference of 4 lb. was due to the compression of the enclosed air, and showed that the absolute internal pressure was about 19 lb., or 1¼ atmospheres.

The pungent smoke from the burning cables was rapidly filling the control room, irritating eyes and throat; we were all half dead owing to the high air pressure, and it was with difficulty that orders could be heard. The burning cables were at the back of the switchboard, and any attempt to smother the flames by means of wet sacks applied by hand were frustrated by the electric shocks received from the highly-charged switchboard. A chart table drawer was hurriedly smashed and some time was spent extinguishing fires by poking wet sacking on to the burning cables by means of splinters of the drawer bottom.

Stock could now be taken of our position. Repeated telephone calls to the engine room met with no response, and we feared the worst for our comrades in that portion of the ship. A considerable quantity of compressed air was expended in blowing water from the forward tanks, but no effect was produced on the air bubble indication of trim, and as our reserve of compressed air, already largely used up by the earlier dive, was running low, these efforts were stopped. Luckily our batteries were very fully charged, and we were able to use current freely for lighting, pumping and air compressing. The compressors were run for a short time to reduce the air pressure in the hull and to relieve our ears. This, no doubt, threw additional strain upon the after bulkhead of the space free of water, but it successfully bore this extra load. We were unable to blow any water or oil out of the after tanks as the valves controlling these were all in the engine room out of our reach. Nor could the after drop keel be released, though the forward weight was free.

As it happened, the captain of E. 50—which was in the Gareloch on diving trials, had been watching our dive and "did not like the look of it." He dropped a buoy to mark the spot, and came over to meet Comet, which was now returning to stand by.

Shortly after settling down, we began to open the watertight doors again to obtain more room and more air. The watertight door leading to the submerged torpedo room was cautiously opened, releasing the two men who had been shut in. The compartment found to be practically free of water, though its after bulkhead, constructed to withstand a pressure of 15 lb. per square inch and now enduring nearly 25 lb., was leaking freely and a considerable quantity of water was coming through the voice pipe, and the glands for cables, telegraph shafting, &c. Meantime, water was gaining at the rate of about 2 ft. per hour in the amidships torpedo compartment, and at intervals the electric bilge pump had to be run for short periods to eject this.

Those in the forward portion of the ship were: Captains Herbert and Goodhart, Lieutenants Singer and Rideal; Messrs. Searle, Cocks, Renfrew, Black, Wallace, Hepworth, Hancock, Duncan, Hood, McLean, Skinner, Struthers, Bullen, Green, Kerr, Hillhouse, Lake, Powney, and 26 naval ratings. For these 48 persons the available air space was about 12,000 cub. ft., giving about 250 cub. ft. of air per person. Air contains about 20 per cent. of oxygen, and if this be reduced to 16 per cent., human life is extinguished. Each of us had, therefore, an allowance of oxygen equal to 4 per cent. of our air ration, or 10 cub. ft. of oxygen per head. Now a human being at rest consumes about two-thirds of a cubic foot of oxygen per hour, and at this rate we should have been able to live for $10 \div \frac{2}{3} = 15$ hours. If we had to work, the rate of consumption of oxygen would be very much greater, hard work involving a consumption nine times as great or 6 cub. ft. per hour. Most of us had nothing to do, and I assume that we were using oxygen at an average rate of about 1½ cub. ft. per man per hour. At this rate, unless the air could be renewed, our allowance of oxygen would last only 8 hours.

We actually carried on for about 42 hours on what air we had. This we were able to do by drawing upon our compressed air supply, and at intervals Mr. McLean allowed a small quantity to escape into the torpedo room and at the same time forced some of the vitiated air back into other bottles by means of the air compressor. On Tuesday the air was so bad that a match when struck produced only a slight smoke but no flame. As the

* Paper (slightly abridged) read before the Greenock Association of Engineers and Shipbuilders.

oxygen was used its place was taken by the carbon dioxide exhaled. One per cent. of CO_2 is distinctly smellable, and produces dyspnœa (which is what the medical men call panting); at 3 per cent. the panting becomes painful, and at 5 per cent. all exertion becomes impossible. As the air in our submerged prison became more and more impregnated with carbonic acid, so did our breathing become more and more difficult, and we had to inhale and exhale with painful rapidity. For some the process was carried on only under great pain and difficulty. Many found standing the easiest posture. And so the long night passed away.

When day broke, about 8 o'clock on Tuesday morning, we could see a greenish light through the periscope. Some specks on the glass gave the illusion of a light green sunlit sea with a man rowing in a small boat, and it was only the immobility and constancy of the picture that assured us of its unreality. Through the bullseyes in the sides of the conning tower we could distinctly see the wire guard rail which ran around the topsides.

At the time of the accident the hydraulic system, which worked the periscopes and the wireless masts, was running on the after pump in the engine room. This was disconnected (someone kindly advancing half-a-crown to be used as a blank flange), and changed over to the forward pump.

About 8 o'clock we heard heavy footsteps and tappings on the outside of the hull. But so drugged were we by the bad air that we had become almost indifferent, and the knowledge that help was at hand roused no enthusiasm, not even a cheer. We tapped back again, and tried to establish communication by means of the Morse Code. But for some reason this did not go very well and no messages were conveyed beyond knowledge to us that we had been found and news to the surface that someone within the vessel was still alive. The diver departed, and we had another long spell of waiting, with occasional startings of the pump to clear water from the amidships torpedo room. This was necessary both to reduce the weight in the boat and to prevent the water from ultimately reaching the batteries under the control room. And now our two brave commanders, Herbert and Goodhart, who had been earnestly conferring with each other over our desperate situation, made up their minds that one of them should endeavour to reach the surface by way of the conning tower, and as the captain of a ship is supposed in all cases of abandonment to be the last to leave, Commander Goodhart undertook to make the attempt. The conning tower (Fig. 4) was a heavy brass casting, elliptical in horizontal section 5 ft. 6 in. long by 3 ft. 6 in. wide and 4 ft. 6 in. high. It was reached from the interior of the vessel by way of a hatch having a watertight hinging cover opening upwards into the tower. The after portion of the roof was occupied by the exit hatch with a balanced watertight cover opening upwards into the chart room. The forward portion rose to a further height of 3 ft. 6 in. in the form of a dome, 2 ft. 6 in. by 2 ft., designed to carry the projector compass at a sufficient distance from the steelwork of the main hull. Each hatch could be opened and closed only from its underside. On each side was a glass bullseye, fitted with prisms which enabled an observer to see ahead as well as on the beam.

There were fittings of many descriptions in the tower, but those of direct importance to the captain's plan were as follows: An electric lamp, suspended from the top of the dome. A fuel vent pipe, 1 in. in diameter, leading from below and cut through the after side of the tower, with a valve on the inside. The projector compass tube leading down to the control room and fitted with a valve inside the main hull. A high-pressure air pipe leading up to the whistle and fitted with valves inside the main hull and within the conning tower (Fig. 4).

In preparation for the proposed escape, the vent pipe was removed below the valve, so that by opening the latter sea water could be admitted to the conning tower. The projector compass and its tube were removed so as to leave more room in the tower and dome, and so that the lower portion of the pipe within the control room could be used as a drain pipe to carry away water from the conning tower. A flexible hose was attached to the lower end of the pipe and led into the broadside torpedo room. The whistle pipe was broken at a joint and a valve taken from an inboard position was fitted on the upper end of the pipe leading from the high-pressure air system. By this arrangement compressed air could be admitted to the conning tower by opening both the valves described—the new valve specially fitted within the tower and the original valve in the control room. The air could be shut off by either valve.

The commander's intentions were that both officers should enter the tower and close the lower door, which would be clipped from below. They would then unclip the upper door, open the sea valve and gradually flood the conning tower, forcing up the air in it until its pressure became equal to that due to the head of sea water upon the upper door. This, being balanced, could then be easily opened, the two occupants of the tower standing with their heads in the dome from which the air could not escape. The water in the conning tower at this time would be about 3 ft. deep, but as soon as the lid was raised, the air above this level and below the dome would, of course, escape and be replaced by an inrush of sea water. High-pressure air was then to be turned on and, aided by its outflow, Commander Goodhart was to pass through the upper door and endeavour to find his way through the chart room door and swim to the surface. As soon as he had gone Herbert was to shut off the air supply, close and clip the outer door and knock loudly on the inner hull with an iron rod placed within reach for that purpose. This was to be the signal for those within board to open the drain valve, and as soon as this was done Herbert could let a small amount of compressed air into the tower to take the place of the outflowing water and even to accelerate its going. Those within board were to watch the water flowing from the drain pipe, and when it ceased to flow unclip and open the lower door and receive Herbert, who would meantime have closed the air valve, back into the vessel.

While these preparations were going forward, a small tin cylinder, which I had brought with me to hold a hydrometer, was prepared to carry a message to the surface in case Commander Goodhart himself failed in his attempt. Many of the prisoners wrote farewell messages to their people, and these were all given harbour in the cylinder. A list of the then survivors was also enclosed. It was a well-laid scheme, but like many such it went "agley."

We afterwards learned that the two commanders had opened the sea cock and had stood till the ice-cold water had reached their middles. Their ears were drumming and deafened by the high pressure of the air, a thick fog filled the upper space and rendered the electric light useless. Then the door was lifted, air turned on, Goodhart passed up through the hatch. Herbert stepped forward to close the hatch, but the rush of the expanding air was so great that in spite of himself he was forced upwards through the opening and into the wheel-house, and then by pure good luck was carried by the escaping air aft and up through the hatch in the after end of the wheel-house roof. He partly swam and was partly carried by the ascending air to the surface, breathing most of the time, and brushing aside the "wireless" wires as he passed. He came up close to the diver's boat, and the diver, who was standing on his ladder with helmet off, grabbed him and helped him on board. Herbert's first words were "Where's Goodhart," and we can imagine his horror when he was told that he had not appeared. Nor had the tin cylinder reached the surface, and long afterwards the brave commander, who truly gave his life for all of us, was found in the forward part of the wheel-house. It is supposed that he was shot violently upwards by the rush of air and was stunned by contact with the wheel-house roof.

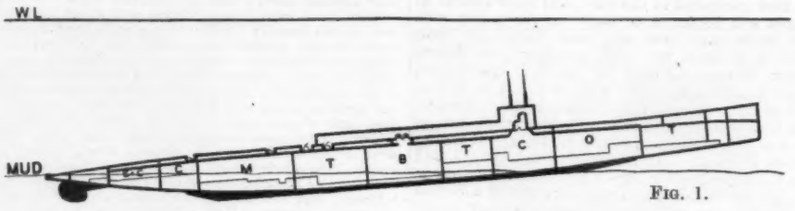


Fig. 1.

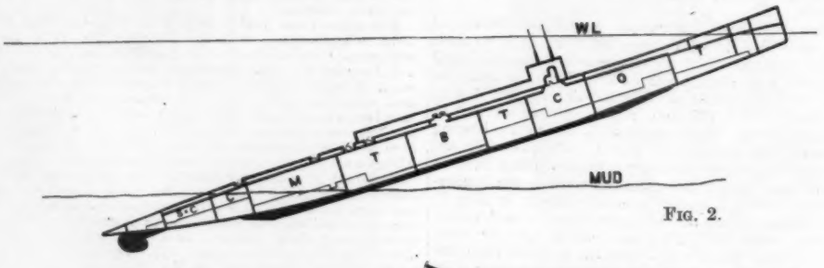


Fig. 2.

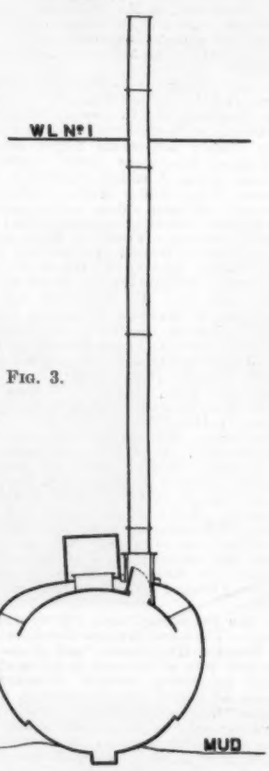


Fig. 3.

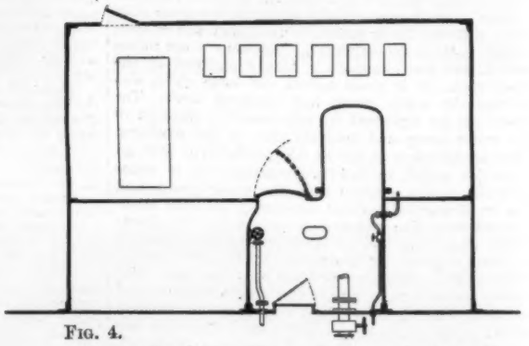


Fig. 4.

Of all this, of course, we knew nothing at the time, though we speculated much, and settled down again to another period of waiting, broken only by periodical startings of the bilge pump and high-pressure air compressor. Herbert's arrival on the surface was a godsend to us all, however, as he was able to give the rescue party definite details as to our condition and to advise as to the best means of assistance.

Our rescuers, with all the will and all the resources of the Clyde at their disposal were terribly handicapped by want of exact knowledge of our circumstances. All that was known was that K. 13 had gone down and had not come up again, and that she was probably not at the bottom of the Gareloch from choice. When morning dawned divers and craft of all kinds were on the scene, and Captain Young, giant among salvors, and his famous salvage vessel Ranger, were *en route* from Holyhead. From the commencement of the war Captain (now Commodore Young, R.N.R.) was appointed H.M. Naval Salvage Adviser, and severed his connection with Liverpool for the duration of the war. The salvage ship Ranger was transferred to the Navy, and became one of H.M. salvage ships. It so happened that H.M. salvage ship Thrush was at Greenock at the time of the accident, having just completed the salvage of the Mavisbrook at Loch Maddie, and this vessel proceeded at 6 a.m. the following morning for the scene of the accident, together with a number of other vessels, including two Clyde hopper barges and a trawler—the operations being then in charge of Admiralty Salvage Officer Commander Kay, R.N.R., until relieved by Captain Young, who arrived shortly after Commander Herbert came to the surface.

Wire ropes were placed under the bows of the submarine and attached to the two Clyde hoppers, and also from the salvage vessel Thrush to the trawler on the opposite side. Many schemes were projected and discussed. The first object was to save life, and thereafter to salve the vessel herself. If, as appeared probable, the submarine was too heavy to be lifted by main force so as to bring her crew to the surface with herself, then the crew must be brought up without the ship. Captain Herbert suggested a rescue tube, and the necessary instructions reached Fairfield just after stopping time on Tuesday evening when staff and workers were homeward bound. Hasty recalls were issued. A steel tube 27 in. in diameter and 60 ft. in length, with a box at one end

was at once made and arranged to be fitted over the outer hull in way of the 'midship torpedo hatch and caulked watertight (Fig. 3). This was to be fixed in place by divers and guyed to the hull. A discharge pipe was attached to its lower end and carried up to the surface on the outside. The top was to be temporarily closed by a bolted plate, and the water in the tube blown up the discharge pipe. The cover could then be removed so that someone—and preferably someone small—could be lowered and get us to open the torpedo hatch, when one by one we could have been hoisted to freedom. But it was not known if we were even able to open the hatch, much less lift it, and so it was thought that it might become necessary to cut a hole in the cover. This would have to be done by means of the oxy-acetylene flame, and would be by no means a pleasant but in every way a risky job. All night the ironworkers and carpenters wrought at the tube, box and pipe; never perhaps had men worked so eagerly and so strenuously, and the whole was complete within seventeen hours from the beginning of preparing drawings. The tube was never used, but none the less it was a noble effort, and might have been of vital importance.

The result of Herbert's efforts became evident to us at about 6 o'clock on Tuesday evening when we were made aware by tapping on the hull that a high-pressure connection had been made to our air system. There was a branch from the air system led outboard for gunnery purposes and to enable air for recharging the air bottles to be received from the shore or from another vessel, and to this a flexible air pipe had been connected. We slightly opened one of the joints in the system and cautiously opened the inboard valve. To our disappointment we obtained not the air we so much needed, but salt water mixed with a few air bubbles. We caught this water in buckets and removed bucketful after bucketful, hoping that we would soon come to an end of the water and get to the air. But at last we had to close the valve and try to tap out a message to say what was happening.

Then followed another long wait while the diver disconnected and overhauled his air pipe, to find the cause of the trouble in a blank flange where no blank flange should be. This was put right and we got pure dry air. A little of this was allowed to escape into the hull, and then the joint was made tight and we proceeded to recharge our exhausted air bottles. This was about 4 a.m. on Wednesday morning, when we had been below for about 37 hours. About this time the diver hung an electric lamp in front of the eye of the periscope. This Morsed messages to us—if we happened to be looking—but, of course, we had no means of signalling back. About 5 a.m., as soon as we had charged up several groups of bottles to their full pressure of 2,500 lb., we began to blow out all the forward tanks within our control, namely, the seven foremost external tanks and the internal tanks forward of the boiler room. As we had no means of knowing when these were emptied we had to guess how long to keep the air on each, but as our supply was now ample we made reasonably sure that each was completely blown before passing to the next.

Anxiously we watched the bubbles of our fore and aft spirit levels for some sign that the bow was lifting, but for a long time nothing happened. Tank after tank was given its quantum of air, but the bubble remained motionless at 4 deg. up by the bow. We had almost given up hope when we began to blow into almost the last remaining tank. And then the bubble moved! We gave a shout of delight, and watched the cheering indicator as it slowly moved to 5 deg., 6 deg., 7 deg., 8 deg., 9 deg., 10 deg., and that was as far as it was made to go—it could go no further. Wire cables had been passed under our bows from the salvage vessels and an attempt made to raise the submarine by this means, but without success—as our fore end lifted these cables were observed to slacken and were at once pulled taut so as to hold what we had gained. But the vessel continued to rise forward, the decks became steeper and steeper, until at last those on the surface saw our bow rise out of the water, and presently signalled to us that we were high enough and had better not blow any more as the escaping air was endangering the diver. At this time the vessel lay with her stern some 12 ft. deep in the mud and her stem head about 10 ft. above water, the angle of longitudinal inclination being about 16 deg. When the bow was raised we could see clearly through the periscope, which was now above water, and watch the work of rescue, and we were able to recognise those on board the lighter (see Fig. 2).

The great inclination brought another trouble. The bilge pump was now raised so high above the after end of the torpedo room that it would no longer function. As we were in constant fear of the incoming water rising so high as to enter the control room and reach the batteries, we started to carry it in buckets to one of the forward bilges. This was a slow and wearisome process, as we had but two buckets—one of which leaked—and the steep and slippery deck made our footing very insecure. We formed a queue, each member of which held himself in place by one hand and passed the buckets along with the other. This work continued for some time, until Mr. McLean and Mr. Bullen hit upon a better plan. They took off the cover of the manhole to the tank under the torpedo room and allowed the bilge water to pour into the tank. When the tank was nearly full, the manhole was closed, high-pressure air admitted to the tank and all the water blown out. The manhole was then reopened and the process repeated as before. Incidentally this operation helped to renew our air, as each time the manhole was opened some of the compressed air in the tank expanded into our living spaces.

By this means the water was kept well under, and it never came near to the batteries, although at one time our rescuers by some misunderstanding were led to believe that we were in imminent danger of chlorination.

Meantime, another connection was made to the hull. There was a 7-in. ventilator and hand-up which passed through both inner and outer hulls from the officers' quarters. This had a screwed cover on top and a hinged cover below. The top cover was removed by the diver, a hole cut in it, and a 4-in. flexible armoured hose securely attached. The cover was then replaced, and most of the water sucked out of the pipe by means of a smaller suction hose. Word was then tapped to us to open the hinged cover. This we did very cautiously, and found that after a considerable quantity of water had come down air began to rush strongly out of our prison, showing that the pressure was still considerably above that of the atmosphere. The escaping air was so black and foul that our salvors marvelled that any one could still be alive. The boiler-room bulkhead responded to the reduction of pressure by leaking more rapidly, but luckily did not give way under the additional load caused by the reduction of air pressure on its forward side.

We could now talk freely with those on the surface, and our first inquiry was for Herbert, as our impression was that Goodhart had reached the surface, but that Herbert was still in the conning tower. He replied himself, to our great joy. It was not till much later that we learned that Goodhart had been lost.

The diver had found explanation of the disaster by discovering that the four air inlets to the boiler room were fully open. These should, of course, have been closed before the signal "Engine-room closed" was set in the control room, but by some oversight this had not been done. The accident was thus not due to any defect in the design or construction of the vessel, but to a momentary forgetfulness on the part of someone who paid for his error with his life. When the vessel was ultimately examined, the lever controlling the air-inlet covers was found to be standing at "open."

The 4-in. tube, besides making communications as easy as they had previously been difficult, was large enough for the passage of small articles, and presently a small bottle of brandy was seen to be dangling on the end of a string. This was served round sparingly, the dish used being the brass cover of an electric switch. Next came milk and chocolate, liquid and solid. No one was anxious to eat; we had on board at the time of the accident a supply of sandwiches enough to afford about 1½ per person; these were passed round about 6 o'clock on Wednesday morning, but very few were eaten. Thirst was our principal trouble.

A high-pressure air pipe was passed down the 4-in. flexible hose. As the hull became filled with fresh air and the foul air was expelled, we all revived wonderfully, and hope began to speak again in a timid manner, though no one voiced his hope as it was felt that at any moment, and in any of many forms, disaster might come. All along we had had in our minds the possibility that we might have to retreat from the control room if the boiler-room bulkhead showed signs of giving way, and a good deal of work was done by Mr. Skinner and others in altering electric leads so that we might be independent of the switchboard and of the after battery under the control room. But the bulkhead held, and these arrangements did not have to be put into operation. While connecting a wandering lead to the starter of the air compressor one of the men accidentally made a short circuit, which blew out the main fuse and suddenly plunged the whole interior into darkness. The last 6 hours or thereabouts of our imprisonment were spent in total darkness, relieved only by one wandering lead from the switchboard, two magazine hand lamps and one electric torch.

Meantime, the problem of getting us out was exercising the minds of those on the surface. It was thought that we might possibly utilise one of the bow tubes as an exit, but when we cautiously eased the inner cover we found that the tube was fully flooded, and so had to screw the cover tight again. It was then decided to pump away the water lying between the main hull and the superstructure forward, to cut a hole in the deck and another directly below it in the main hull. Finally, a space just aft of the tank bulkhead was chosen. The oxy-acetylene flame was set to work and soon the anxious watchers below saw its point burst through the roof of their prison. A hole about 18 in. square was quickly cut, Lieutenant Singer gave the order "Civilians first," and amid resounding cheers from the men crowding the decks of the rescue vessels we began to appear one by one out of the depths and on to the deck of K. 13. Forty-eight men came out. The last man to come out was, as it should have been, Lieutenant Singer, who, with Mr. Wallace and myself had gradually passed forward from compartment to compartment, carefully closing the watertight doors behind us as we made our way forward.

Stout steel hawsers had been passed under K. 13 to help to raise her bow and to hold her up when raised. As water slowly leaked into her hull, and was no longer kept in check by the pumps, the strain upon these hawsers became so great that about 6 o'clock on Thursday afternoon the bollards were torn out of the supporting barges and K. 13 again sank to the bottom.

The salvage party closed up all openings in the inner hull and fitted to each compartment two pipes—an air supply pipe led from the surface and just through the crown, and a water discharge pipe led from the surface, passed through the top of each space and pushed downwards as near to the bottom as possible. The water was thus gradually driven out of the vessel, and about six weeks later she bobbed up as suddenly and as unexpectedly as she had gone down.

Two men were missing. They had evidently opened the engine hatch, the pressures on each side of which would of course be equal, and had managed to reach the surface, only to be overcome by the sudden reduction of pressure and to become unconscious and sink again into the Gareloch.

K. 13 returned to Fairfield to be completely gutted out and renewed, and was before very long again passed as "fit for service."

In conclusion, I desire to give expression to my admiration, for the untiring services rendered within K. 13 by Messrs. McLean, Skinner, Bullen, Struthers, Green and Searle, who were indefatigable in doing all that had to be done, and who knew every pipe and valve and switch in the vessel; to the lively gratitude of all the survivors to the two brave commanders who met such great risks on our behalf, and to all of the Admiralty, Salvage, Hydropathic and Fairfield departments who worked so hard towards our rescue and recovery.

In April the following letter was received by the Fairfield Company:—

Admiralty, S.W. 1,
April 22, 1917.

Gentlemen,—My Lords Commissioners of the Admiralty, having had under their consideration the minutes of proceedings of a Court of Inquiry held on the 19th ident., to investigate the circumstances attending the accident to and subsequent foundering of H.M. Submarine K. 13, I am commanded by their Lordships to request that you will convey to Mr. William McLean, Mr. E. J. Skinner, and Mr. F. Bullen, an expression of their appreciation of their services on this occasion, which undoubtedly contributed materially towards the saving of the survivors.

I am, Gentlemen, your obedient servant,
(Signed) O. Murray.

Commander Goodhart received posthumous award of the Albert Medal for gallantry in saving life at sea.

CATALOGUES.

Small Fans.—A variety of desk, ceiling, wall and window fans with motors is shown in a new catalogue issued by the Sun Electrical Company, Limited, 120, Charing Cross-road, W.C. 2. Another catalogue shows electric sign flashers.

Steel Piling.—A monthly bulletin issued by the British Steel Piling Company, Dock House, Billiter-street, E.C. 3, contains interesting information about their sheet piling, which consists of joist shaped piles joined by clutch section piles.

Electric Wires.—Electric wires, cables and flexibles made by the General Electric Company, Limited, at their Southampton works, are now obtainable in large quantities, and electric lamps made at the company's Hammersmith works are supplied at reduced prices. On one of the leaflets there is an interesting note on the gas-filled (¼-watt) lamp and its manufacture, which might be printed in larger type in future editions.

Milling Cutters.—A catalogue issued by the Brooke Tool Manufacturing Company, Limited, Greet, Birmingham, gives a very large range of sizes (hole, diameter and length) of all the usual types of milling cutters, with prices in carbon steel and high-speed steel for each size. Slot, plain, side and face, end, single and double angle, concave, convex, gear tooth, thread, hobbing, and many others; also special cutters for twist drill grooves, tee slots, &c., and a large variety of slitting screws.

Rolling-Mill Motors.—A long list of reversing and continuous rolling-mill electric motor equipments made by Messrs. Siemens Brothers Dynamo Works Company, Limited, Stafford, is the subject matter of a catalogue recently issued by this firm. The names of the firms include many British iron and steel, tin-plate and tube companies. The listed particulars are: Horse-power, speed, type and voltage of motor, and the type of mill driven, with diameter and speed of rolls and type of drive. The powers range from 19,000 h.p. to 42 h.p.

Outdoor Electric Gear.—A pamphlet describing switches, transformers, &c., of large power at work under full exposure to the weather has been issued by the British Westinghouse Company, Limited, Trafford-park, Manchester. It is written by Messrs. S. Q. Hayes and W. A. Coates, and describes circuit-breakers, an electrically-operated oil switch of 135,000 volts and several others. The particulars are interesting, and stated in a clear and informing style; but most British engineers will think that the cost of a substantial shed would repay itself.

Automobiles.—The National Automobile Chamber of Commerce, New York, has issued the sixteenth (1919) Handbook of Automobiles made by American firms who are members of the Chamber. About 190 types of passenger and commercial automobiles are shown, a single page being given to an illustration and specification of each. The preface states that the 1918 American production of passenger cars was reduced to 60 per cent. of the 1917 output, while the production of "trucks" (i.e., lorries and vans) substantially increased. The simple arrangement of this book, with full indices, make it very useful for reference.

Aerial Ropeways.—The British Ropeway Engineering Company, Limited, 34, Fenchurch-street, E.C. 3, a new all-British company which acquired Bleichert's business has issued a series of illustrations of ropeways constructed by them during the war. These have carrying capacities of 7 tons to 40 tons per hour and include mono-cable and bi-cable types in continuous action and one example of a to-and-fro bi-cable type. As these terms are not literally self-explanatory it may be noted that a mono-cable means a single endless moving cable which supports and travels the load; while a bi-cable means two fixed cables which only provide support and travelling surface for the load, the haulage motion being imparted by a third and endless cable.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Name, &c., of the Communicators are given in italics.

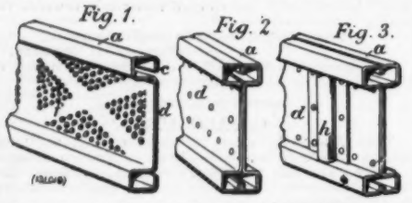
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

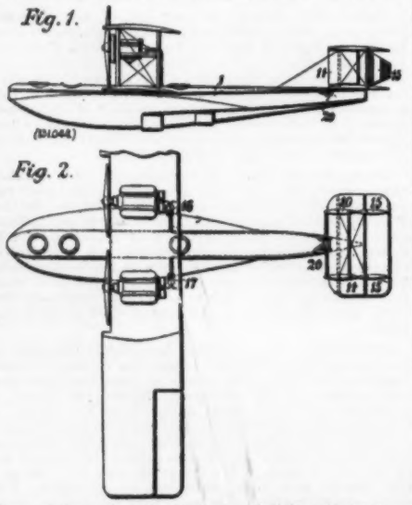
AERONAUTICS.

131,019. D. J. Mooney, Westminster, London. Aircraft Structural Members. (24 *Figs.*) March 21, 1918.—This invention relates to spars, girders, longerons or the like for aircraft formed of thin metal strips shaped to give stiffness and strength with light weight. A spar, according to this invention, consists of two members, each made up of channel form section, made from a strip of thin metal whose edges serve as flanges by being bent into square or rectangular shape projecting from the flat part of the web. In Fig. 1 is shown a single member formed



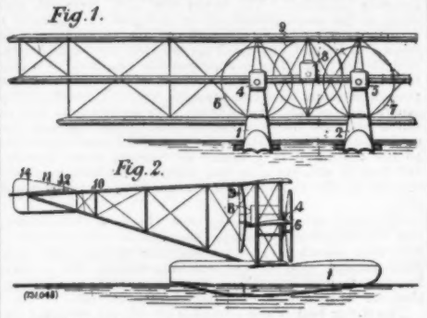
out of a strip of thin metal, the flange *a* being bent round to a rectangular shape with well-rounded corners, the edges *c* nearly forming closed rectangular tubes, the web *d* being pierced with holes preferably small and round, leaving spaces *f* as unpierced flats in the direction of the stresses. Fig. 2 shows two single members with the webs *d* touching and riveted together, the edges *c* of the flanges touching so as to support each other and prevent buckling. Fig. 3 shows the same with supports *h* of channel shape for the flanges which also stiffen the web *d*. (*Accepted August* 27, 1919.)

131,044. H. O. Short, Rochester, Kent. Aeroplanes. (4 *Figs.*) April 3, 1918.—The invention refers to aeroplanes fitted with multiple or twin engines arranged on opposite sides of the longitudinal axis of the machine. The object of the invention is to provide means whereby failure of one of the engines can be efficiently counterbalanced without employing the usual rearwardly located vertical rudder or rudders for this purpose. According to this invention, the vertical fin or fins 10, 11, carried at the rear of and upon the hull or fuselage 1 is, or are, pivotally mounted upon a vertical axis or axes, and the usual vertical rudder or rudders 15 located rearwards of said fin or fins, is, or are, mounted as usual on a vertical axis or axes independently of the said fin or fins, and usual or convenient means are provided whereby the pilot can operate the rudder or rudders; in combination with this arrangement separate and independent means are provided whereby in the event of failure



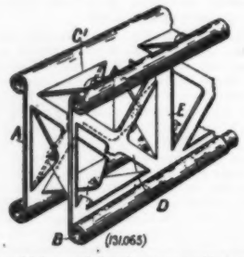
of one of the engines the pilot can adjust the pivoted fin or fins 10, 11, to the requisite angle and maintain the fin or fins at such angle as will be calculated to counterbalance the one-sided effect due to failure of one of the engines without interference with the vertical rudder 15. The invention further alternatively provides mechanism operated from the engines adapted to automatically adjust and govern the position of the said pivoted tail fin or fins, in accordance with the degree of unequal action of the engines, or failure of one of them, to which end air pumps 16, 17, are operated by the engines, regulating by air pressure the position of an operating device 20, such as a piston in a cylinder, said device governing the position of the pivoted fin or fins 10, 11; with such an arrangement when, for instance, one of the engines is unequal in its action to the other, the fins become automatically adjusted and maintained in position to counteract such unequal action. (*Accepted August* 27, 1919.)

131,045. H. O. Short, Rochester, Kent. Hydro-Aeroplanes. (3 *Figs.*) April 3, 1918.—According to the present invention, it is proposed to construct two floats or boats 1, 2, hereinafter termed boats, arranged equi-distant upon opposite sides of the longitudinal axis of the machine, the two said boats being rigidly fixed immediately beneath the lower plane of the wings, the said wings therefore extending transversely across the two boats. These boats are constructed to seat the observer and the pilot, or adapted to carry a pilot in



each of the said boats. In one construction, the wing structure carries a rearwardly-extending tail frame 10 extending between, centrally above, and beyond the boats to support the horizontal tail plane or planes 11, the rudder or rudders 14 and the fin or fins 12, independently of the boats, and where in such a machine three engines 4, 5, are employed, these may be carried between the planes of the wings, two, for instance, 4, 5 above the boats, which engines may drive tractor propellers 6, 7, while the third engine 8 may conveniently be located centrally, and may drive a pusher propeller 9. (*Accepted August* 27, 1919.)

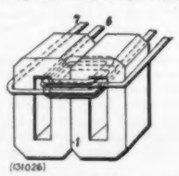
131,065. D. J. Mooney, Westminster, London. Aircraft Structural Units. (2 *Figs.*) April 11, 1918.—The type of structural unit to which this invention refers is that which takes substantially the form of a box girder built up, as usual, with plate-like lateral members. The invention provides in or for aircraft a structural unit of the type defined wherein the web A of each lateral member has tongues C1 punched or otherwise formed out of the metal of its web projecting towards the fellow web and riveted or otherwise secured to the corresponding tongues of the said fellow web. The girder shown comprises two lateral members A, each having its upper and lower edges reinforced by the metal of the web of the member being turned over



to form flanges, which are of circular cross-section, as shown at B, though they may be of oval cross-section, or otherwise formed, for example, of rectangular cross-section. These tubular flanges may be further reinforced by tubes of corresponding cross-section within them, should this be desired. Groups of tongues C1 of triangular shape, are punched in the metal of the web, the number in a group being four, so that a cross-shaped piece D is left in the web to constitute diagonal ties connecting the upper and lower margins of the web. Between each group and the next a vertical strip E is left. After the tongues have been punched they are bent to project towards the corresponding tongues of the fellow web, and the pairs of tongues are then riveted together. (*Accepted August* 27, 1919.)

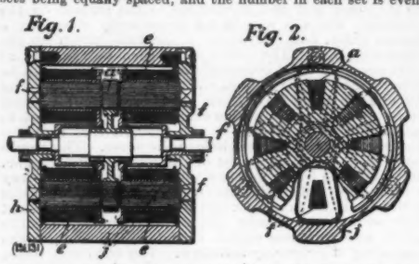
ELECTRICAL APPARATUS.

131,026. J. L. Thompson, Chorlton-on-Medlock, Manchester, and The British Westinghouse Electric and Manufacturing Company, Limited, Westminster, London. Electrical Transformers. (8 *Figs.*) March 25, 1918.—This invention relates to electrical transformers of large capacity giving a comparatively low secondary voltage. According to



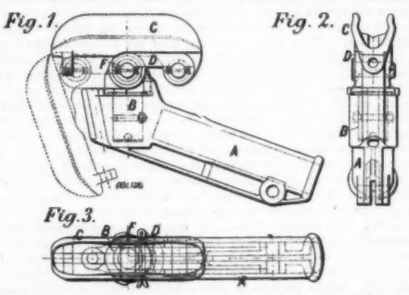
the present invention, some or all of the turns of the low-tension winding are located on the outer portions of the core. The low-tension winding consists of two groups 6, 7, connected in parallel, one of which groups is arranged in association with the central core 1 and one of the outer limbs, the other group being arranged in association with the central core and the other outer limb. (*Accepted August* 27, 1919.)

131,131. Sir W. G. Armstrong, Whitworth and Co., Limited, Newcastle-on-Tyne, C. B. Chicken, Newcastle-on-Tyne, and J. H. Thain, Newcastle-on-Tyne. Electrical Signalling Apparatus. (9 *Figs.*) *August* 12, 1918.—This invention relates to electrical signalling apparatus in which a step-by-step electrical motor is employed for actuating a pointer or the like, which indicates the signals. The object of this invention is to construct a step-by-step motor so that a large number of equal and definite impulses can be received at a high rate without the motor getting out of step with the transmitter switch at the sending station, and that a strong magnetic field is set up, imparting a large torque to the rotating armatures overcoming any partiality to sticking or to sluggishness of the moving parts, and that the magnetic field is so arranged at each impulse that all overrunning of the moving parts is obviated, ensuring a definite step-by-step motion. According to this invention, a set of armatures *a* is equally spaced round an axis and two sets of magnets *e*, *f*, are mounted round an axis, both sets being equally spaced, and the number in each set is even



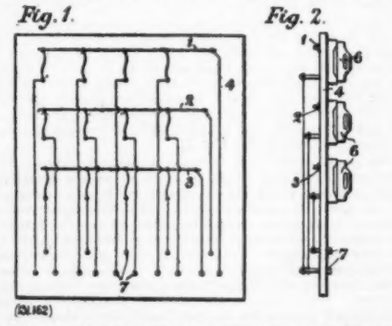
and the number in one is different from and not a multiple of the other number in each of the two sets, the coils of each pair of magnets being connected in series with one another and in parallel with the coils opposite to them, one of the sets, preferably the armatures, being capable of rotation with regard to the other set. The cores *f* of the magnets may be fixed to end frames *h* connected together by a yoke *j*. (*Accepted August* 27, 1919.)

131,136. R. H. Wilkinson, Bradford, and A. R. Fearnley, Sheffield. Current Collectors. (3 *Figs.*) August 13, 1918.—This invention has reference to sliding-contact current collectors for electrically-propelled vehicles. According to the invention, the trolley head makes sliding or rubbing contact with the overhead conductor, and is carried, as ordinarily, on the end of the trolley pole, being secured thereon by means of a socket A that is clamped to the pole and carries the contact-making part of the current collector. This contact-making part is mounted on the socket A, so as to be capable of movement relative thereto, preferably on a spindle B which is rotatable about a vertical axis. The contact-making part of the trolley head comprises two superimposed members C and D pivotally connected together, the lower member D, in the form of a pair of links, being also



pivotally connected to the spindle B or to the socket A. The upper member C is of a grooved extended form to partially embrace the overhead conductor. The arrangement is such that the contact-making part of the trolley head is capable of movement in two planes, the one horizontal and the other vertical. These two movemets permit of the contact-making part of the trolley head following the overhead conductor and maintaining the full area of contact therewith. If the overhead conductor or a span wire be caught between the socket A and the forwardly-extending link member D, the latter will be turned about its pivot F, carrying with it the rearwardly-extending superposed member C, the members C and D assuming the dotted-line positions (Fig. 1), so that the conductor wire or other obstruction is instantly and automatically released. (*Accepted August* 27, 1919.)

131,162. R. T. Norton, Birmingham, and A. C. Robinson, Birmingham. Electrical Fuse Distribution Box. (2 *Figs.*) August 21, 1918.—Apparatus according to the present invention comprises a box or support 4 containing on its front side a number of fuse carriers 6, each of which has a pair of terminals which project upon the opposite side or back of the box or support,



one of each pair of these terminals being there connected to the phase wires or bus-bars 1, 2, 3, and the other of each pair of these terminals being permanently electrically connected at the back of the support to a terminal 7, which passes to the front side of the box or support and is there provided with means for securing the service cables. (*Accepted August* 27, 1919.)

Scientific and Industrial Research.—Sir Henry Alexander Miers, D.Sc., F.R.S., vice-chancellor of the University of Manchester, has been appointed by an Order of Council dated October 16, 1919, to be a member of the Advisory Council to the Committee of the Privy Council for Scientific and Industrial Research.